Hydraulics & Pneumatics

THE MAGAZINE OF FLUID POWER

DECEMBER 1961

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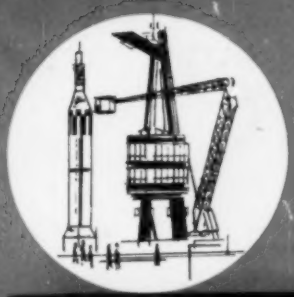

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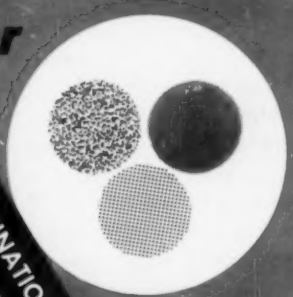
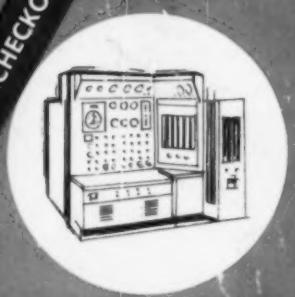


CONTAMINATION CONTROL



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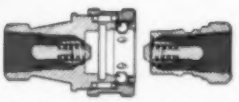

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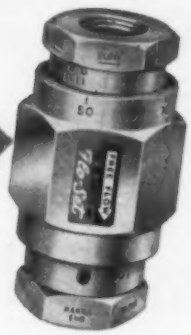

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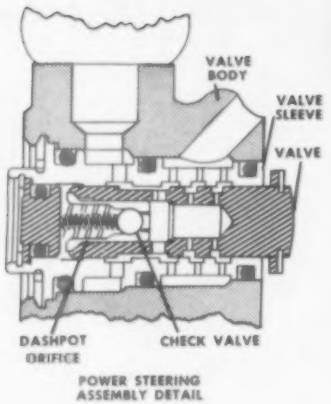

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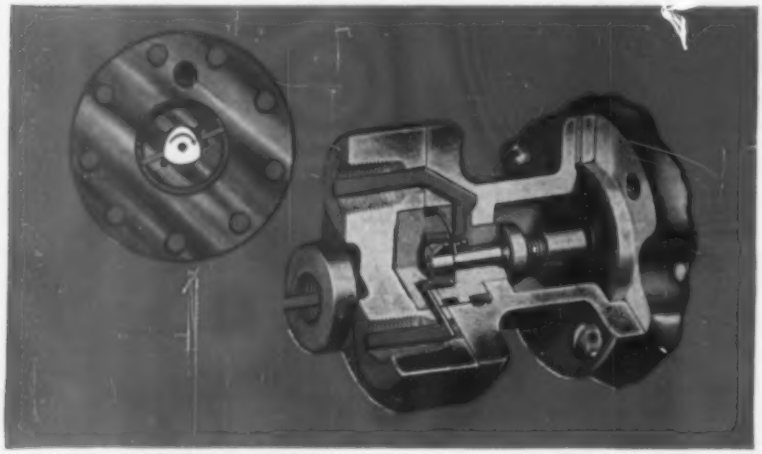

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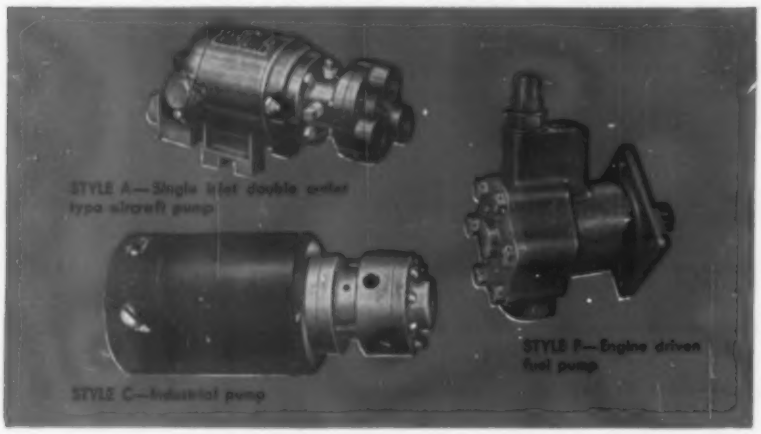

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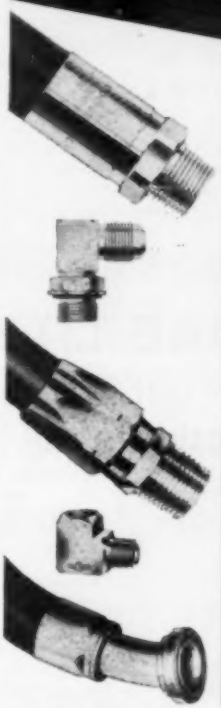

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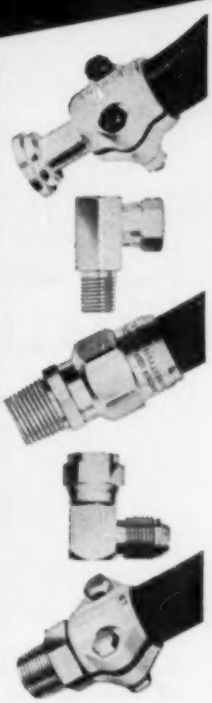

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CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2"—and 2½".
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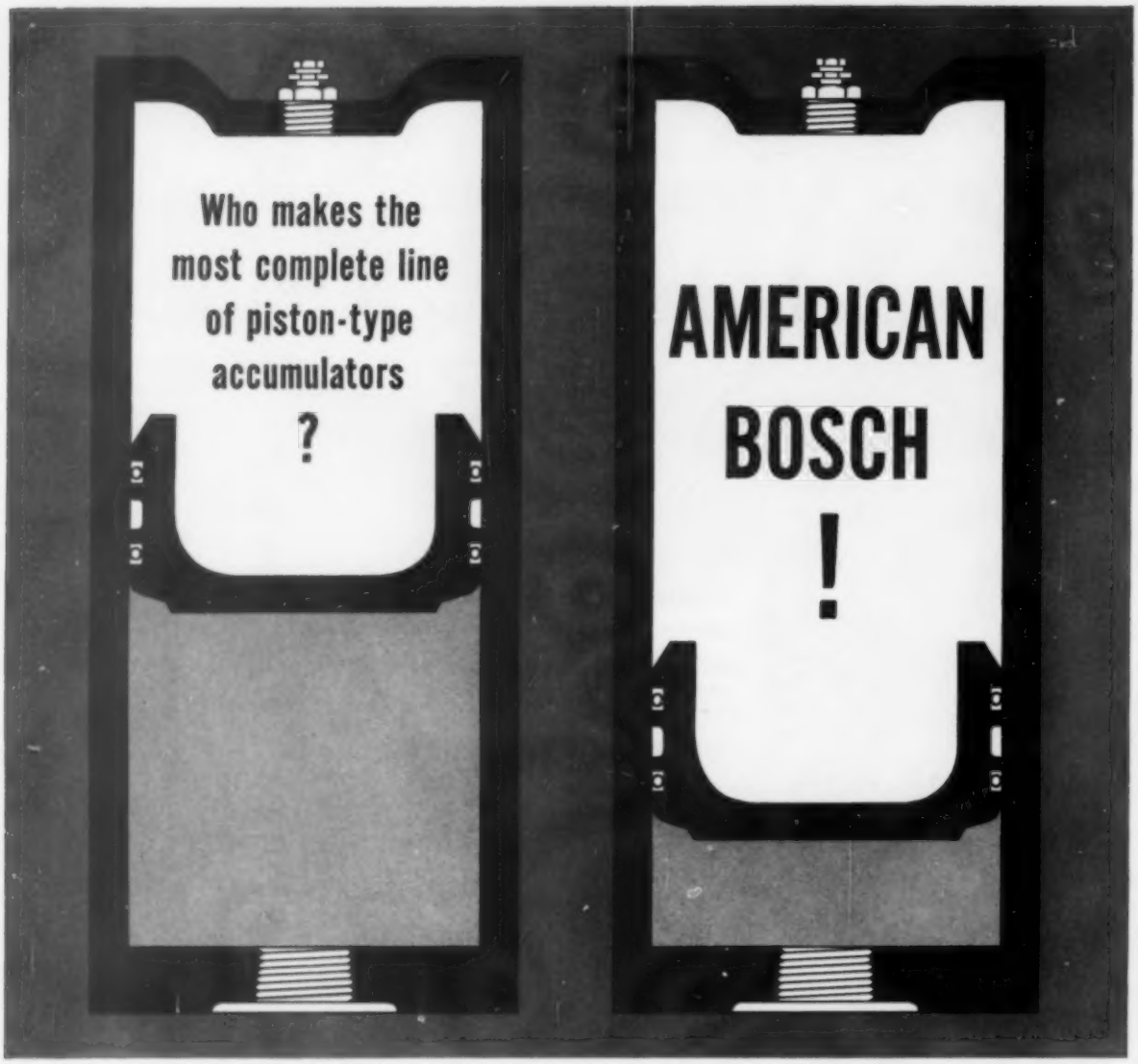

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OILGEAR 40 Years of Fluid Power

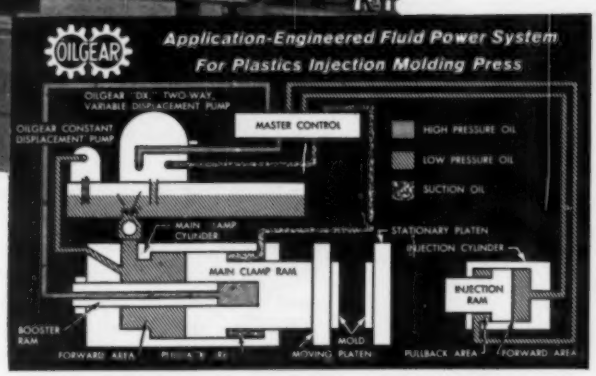
Report No. 11,602 From Oilgear *Application-Engineering* Files

HOW OILGEAR ENGINEERING TEAMWORK AIDED DESIGN OF NEW INJECTION MOLDING MACHINES

CUSTOMER: *National Automatic Tool Co., Inc. (NATCO), Richmond, Indiana*

DATA: As a preliminary guide to design and production of a new line of injection molding machines, "NATCO" engineers used a 31-question survey of molders operating eight or more machines. This survey confirmed "NATCO" engineers' experienced opinion that: 1. Most unplanned downtime on injection molding machines was due primarily to hydraulic system problems . . . shocks caused by sudden shifts in pressure or direction of flow through valves "under pressure," causing pipe and welded joint fatigue, bent valve stems, cracked or over-stressed tie-rods and cylinders. 2 Molders' demands for higher speeds and pressures further amplify these problems. *Basic "NATCO" Requirements:* 1. A hydraulic system to eliminate shock, hammering, and the resulting costly downtime . . . must provide continuous, dependable, high-speed operation. 2. Both slow and high-speed closing, as well as two-speed injection control for faster molding cycles. 3. High-speed clamp action. 4. Precision control of speeds and pressures to insure high molding quality. 5. Must be a "clean" package . . . compact, leak-free, simple to install, fast and easy to maintain, quiet, conserve electrical power.

New "NATCO 400" Plastics Injection Molding Machine — one of four standard sizes. Note overhead position of the Oilgear pump and reservoir . . . away from dirt and molding-room traffic. This position permits fast gravity flow of oil from the reservoir through a prefill valve into the large clamp cylinder to speed operation. During the past year . . . a period of unusually low capital investment purchases . . . over 150 Oilgear Pumps have been put into operation on this new "NATCO" line.



Simplified schematic illustrates one phase of system operation — high-speed closing of clamp ram. Large clamp cylinder is being gravity-filled through prefill valve, while mold clamp is being advanced by small booster cylinder powered by Oilgear "DX" pump. Closing speed — 700 in./min. This circuit design provides clamp pressure build-up in a fraction of a second . . . one of the reasons for the fast cycles on the "NATCO 400."

SOLUTION: Cooperation and teamwork between "NATCO" and Oilgear engineers resulted in a new, shockless, *Fluid Power* System . . . basis of a revolutionary new line of high-speed, high-capacity, plastics injection molding machines. This system incorporates two Oilgear Pumps . . . one, a large capacity, radial piston, two-way, variable displacement type "DX" pump with remote electric control which alternately serves the mold clamp and injection rams; and a small capacity, constant displacement type "HG" pump which maintains a high, positive clamping force during injection cycle. Instead of using conventional valves "under pressure" to reverse clamp and injection rams, these functions are accomplished by reversing fluid flow in the Oilgear type "DX" pump. With this system, flow and pressure decelerates to zero *before* flow direction is changed . . . flow then accelerates to a preselected volume in the new direction — completely eliminating reversal shocks. No chokes or other controls on the master valve are necessary, as diverting of flow from clamp to injection rams is also made under ideal "no-flow" conditions, with absolutely no shock. Infinitely variable machine speeds are obtained by varying pump stroke, resulting in a minimum of heating and horsepower dissipation.

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"NATCO," famous in machine tool and plastic molding machine fields, states — *"Although lower priced pumps could be secured, they basically did not offer the control features found in the Oilgear units. This is especially true of the larger capacity pump, which in addition to its variable and reversible features incorporates many auxiliary controls. It's more than just a pump . . . it contains auxiliary systems for pilot, supercharge, cooling, safety, and filtering. These pumps are quiet. They have an excellent injection molding machine service record . . ."*

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FLUID POWER LINES

from editor to reader

AEROSPACE—FLUID POWER'S VANGUARD

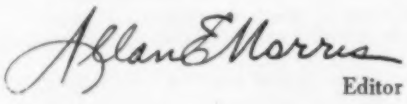
In a fast moving field like aerospace fluid power, examining the state-of-the-art is like looking out the window of a jet plane. By the time you see where you are, you aren't there anymore. Yet the very complexity of hydraulic and pneumatic technology in all the various applications of missiles, spacecraft, and ground support equipment calls for an organization of knowledge, and an evaluation of present and future problems and possible solutions.

The aerospace report beginning on page 67 is such a review. It has been prepared by men who are developing the philosophy, establishing the criteria, and working out the hardware that will strengthen our defense capabilities, and lead our exploration of outer space and the other planets. They have taken time out from their daily tasks to view their projects in relation to the state-of-the-art in their field, and to aerospace technology in general.

We have divided this report into sections on flight control . . . contamination control . . . auxiliary power supplies . . . reliability . . . gas systems . . . ground handling equipment . . . test and checkout equipment. But in working with the contributed material, we became more and more aware of the interrelationships among these areas. Auxiliary power supplies and flight controls for use beyond the atmosphere now depend largely on development of gas systems. These in turn have pointed up contamination problems: the need for better filtering, and components designed to tolerate contamination.

Many of the same problems facing designers of flying equipment are similar for those developing ground support equipment. Cleanliness requirements are just as severe on ground equipment which must supply fluid to the missile. Operation in environments of other planets is just as much of a question mark as vacuum and radiation effects of outer space.

We hope this report will be of interest to those concerned with fluid power on inplant production machines, mobile and marine equipment, and process equipment, as well as those in the aerospace field. Though many aerospace projects seem well into the future in relation to industrial equipment, they may someday be common practice. We've seen many products, originally developed for aircraft, adapted to industrial use: O-rings, servovalves, and straight thread fittings, to name a few. And you need only one conviction for speeding to know how mundane radar can be.

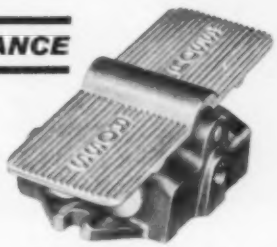


Editor

The world's largest line of air valves is also the most advanced because of the Ross engineering staff

Do you know these Ross air controls?

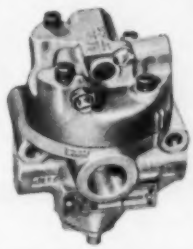
EASY MAINTENANCE



Rugged, dependable foot valve

The 600 valve series. Features maintenance without disconnecting piping, rugged construction and a variety of treadle options: double or single treadle; spring return or detent. Also available as a hand valve. 3-Way and 4-Way models, ¼".

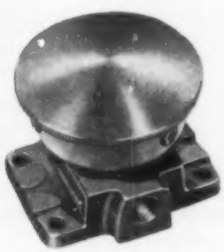
AIR AUTOMATION



Time delay sequencing valves

The Ross Graymodel Valve is actuated by pilot air from another part of the circuit. Times in with cartridge in one position, times out if cartridge is reversed. Adjustable to 0 to 3 second delay.

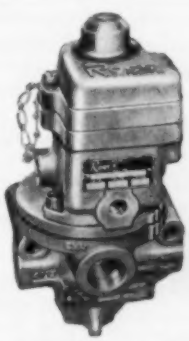
RUGGED



More Comfort for Machine Operator

Push buttons may lead to sore fingers but not this palm button valve. 2⅜" button is comfortably convex. Valve is ruggedly built, available with or without key-locking feature. Red or green button, flange mounting. S-Way or 3-Way.

ECONOMY



Small valve does bigger valves work

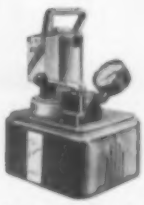
The Pacer Headline Valve gives you highest capacity valve-size for valve-size of any solenoid valve on the market. Capable of rapid cycling, consumes little power. S-Way, 3-Way and 4-Way models. ¼" through 1½" pipe sizes.

For more information write us, or contact your nearby Ross representative. See our digest catalog in Sweet's

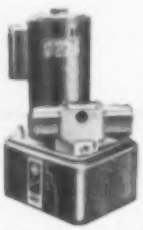
THE WORLD'S MOST COMPLETE LINE OF AIR CONTROL VALVES. AVAILABLE ALL OVER THE FREE WORLD.

Ross OPERATING VALVE COMPANY
105 E. GOLDEN GATE • DETROIT, MICHIGAN

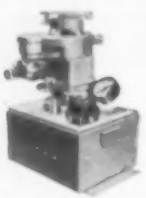
New, unique 2-stage hi-pressure hydraulic pumping units - dual volume and pressure



With 1½ H.P. universal motor, 4-way manual control valve, gauge and 2-gal. reservoir. Wt. 45 lbs.



With 3450 r.p.m. 1½ H.P. jet pump motor, 4-way solenoid valve and 2-gal. reservoir.



With 3 H.P. gasoline engine, 4-way manual control valve, gauge and 5-gal. reservoir.

"Tandem" hookup—two Vanguards in a single 7 gal. reservoir with single 4-way valve; produces twice the volume.

5-Cylinder, Axial Piston Pump (high-pressure stage)—precision-fitted pistons and cylinders are heat-treated, Nitride-hardened and honed to super finish.
Gear Pump (low-pressure stage)—precision fitted gears; hardened, ground and lapped. Supercharges high-pressure stage.

AVAILABLE IN TWO PRESSURE RANGES

- VANGUARD VI, Y-60 Series—For operating pressures up to 6,000 p.s.i.
- VANGUARD X, Y-26 Series—For operating pressures up to 10,000 p.s.i.

New OTC "Vanguard" complete power packages are versatile, precision-built units that handle high pressure, high force requirements, yet provide fast ram approach and return . . . no wasted time in getting the cylinder piston to and from the work!

6,000 P.S.I. MODEL WITH UNIVERSAL MOTOR DELIVERS:		10,000 P.S.I. MODEL WITH UNIVERSAL MOTOR DELIVERS:	
600 cu. in./min. @	100 psi	600 cu. in./min. @	100 psi
400 cu. in./min. @	500 psi	400 cu. in./min. @	500 psi
130 cu. in./min. @	1000 psi	80 cu. in./min. @	1000 psi
90 cu. in./min. @	6000 psi	50 cu. in./min. @	10,000 psi

A wide variety of accessories are available to utilize the "Vanguard's" exceptional performance: choice of motors; gasoline engine; 2 and 4-way lever control valves; 2 and 4-way solenoid valves; pressure switch; pressure regulating valve; manifold; reservoirs; gauges.

For complete information write for our new "Vanguard" brochure, No. V-2.

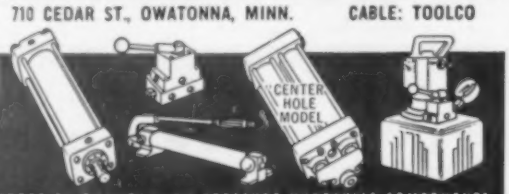
PRECISION HYDRAULICS DIVISION

RESEARCH · ENGINEERING · DEVELOPMENT

OTC

OWATONNA TOOL CO.

710 CEDAR ST., OWATONNA, MINN. CABLE: TOOLCO



DESIGNERS AND MANUFACTURERS OF QUALITY HIGH PRESSURE HYDRAULIC COMPONENTS

Circle 89 on Reader Service Card

LETTERS to the editor

15 ms valve shift

TO THE EDITOR:

Please advise the names and addresses of manufacturers of a compact solenoid valve for hydraulic oil service that has a flow factor, C_v, of 0.4 and will operate in 15 milliseconds.

SOL STROMBERG
Senior Engineer
Automatic Controls Section
Temco Electronics
Dallas, Texas

We have referred you to a distributor of hydraulic and pneumatic components who should be able to assist you in designing your system.

Tubing data

TO THE EDITOR:

We are interested in purchasing a chart of equivalent tubing wall thicknesses for given pressure ranges of various materials such as seamless steel, stainless steel, aluminum, and plastic for hydraulic and pneumatic applications. Do you have anything available?

MARGARET A. FIRTH
Research Division
United Shoe Machinery Corp.
Beverly, Mass.

We suggest that you write directly to the tube manufacturers. They can supply you with the data you need to select tubing for a certain pressure.

Fluid power transmissions

TO THE EDITOR:

We are seeking information concerning use of hydraulics and pneumatics for transmission of motive power.

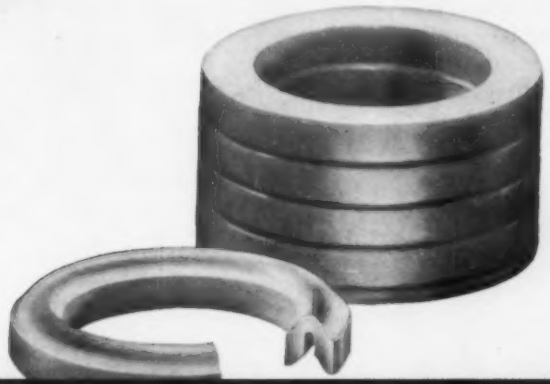
Western Gear Corporation is working on a contract with an agency of the U. S. Government for research on advanced power transmission systems. The objective is to identify and very briefly analyze improved and even radical

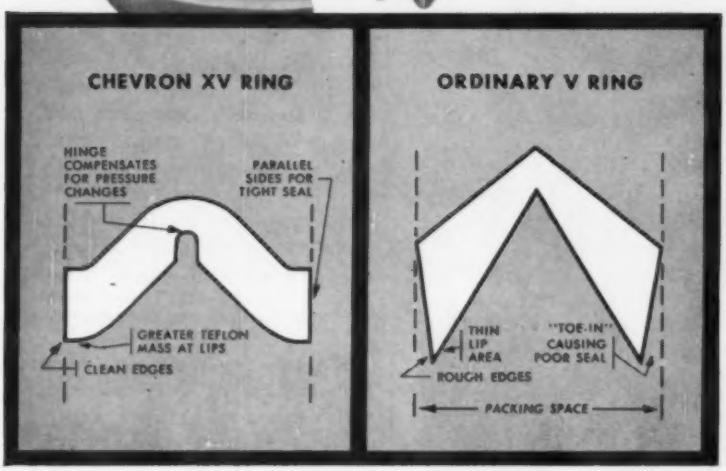
Continued on page 14

NEW

GARLOCK CHEVRON* XV TEFLON† PACKING

for Hydraulic, Pneumatic Service





A new high in V-ring performance and efficiency is here from Garlock in the new CHEVRON XV Teflon Packings. Used for valves, pumps and instruments in corrosive service, this exclusive Garlock design has outperformed ordinary Teflon V-rings in rigid controlled tests. CHEVRON XV is superior in flexibility, freedom from friction, wear resistance and sealing efficiency under varying pressures—withstands pressures to 1000 p.s.i. (rings without hinges available for pressures above 1000 p.s.i.).

Can be molded precisely. The greater material mass of CHEVRON XV permits molding to consistent close tolerances ring after ring—batch after batch. Result—perfect fit, clean lips, far better sealing.

Ends frequent gland adjustment. The exclusive CHEVRON hinge compensates for pressure changes automatically. With proper installation, further adjustments are eliminated.

Greatly extends wear. Greater material mass and parallel sides give Garlock CHEVRON XV PACKINGS much more working Teflon than ordinary V-rings. Sturdier size for size, they wear considerably longer . . . yet cost you no more.

Virtually ends friction because of two factors. First, Teflon has the lowest coefficient of breakaway and running friction of any solid material in use today. Second, the exclusive CHEVRON hinge action permits free operation with minimum friction at all pressures.

Learn the full story of this superior new packing. Discuss your particular needs with your Garlock representative. Call him at the nearest of 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-192, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Co.

Order from the complete line of quality Garlock products . . . Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts.

*Registered Trademark †Du Pont Trademark

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NEED BIG VALVES?

H-P-M makes heavy duty directional and pressure control valves in standard sizes for large flows. 3000 psi; up to 6″ capacity. Designed for greater flow, less pressure drop, better service.

Why buy Specials?

Valve bodies, spools and control elements are easily modified for your specific needs. Patterns — even castings — are often available for fast delivery, lower cost. For complete information, write or call H-P-M — designers and builders of heavy duty hydraulics since 1877.

H-P-M 4-Way Valve; 3000 psi, 450 gpm, pilot operated, flange connections.

H-P-M 4" Angle Check Valve; 3000 psi, flange connections.

H-P-M 3-Way Valve; 3000 psi, 350 gpm, pilot operated, flange connections.

HPM

H230

DIVISION KOEHRING COMPANY

MOUNT GILEAD, OHIO, U.S.A.

Circle **52** on Reader Service Card

LETTERS

solutions to the problem of "converting, transmitting, reducing and controlling power, torque and speed of increasingly higher rpm prime movers."

Any information you can furnish, or suggested sources to review will be deeply appreciated and proper credit given in the final report.

GLENN R. JONES
Western Gear Corp.
Lynwood, Calif.

The articles in this issue represent some advanced projects in hydraulic and pneumatic power. Perhaps they will suggest areas of further study.

Gear type flow divider

TO THE EDITOR:

In HYDRAULICS & PNEUMATICS of December 1959, in an article titled "Single Unit Divides Flow Equally," the author mentions using a positive displacement flow divider of the gear type to divide a single stream of fluid into two equal flows in preference to more conventional dividers. I would like to know more about this divider.

CHARLES DERLER
Research & Development
Jackson Vibrators, Inc.
Ludington, Mich.

We have referred you to the manufacturer of this component which was used by Clark Equipment Co. on a pipe-handling truck.

Cylinders for rotary motion

TO THE EDITOR:

I am quite interested in the application of four hydraulic cylinders mounted in a radial fashion described some time ago in a HYDRAULICS & PNEUMATICS article. I would appreciate your sending tear sheets of this article.

L. S. ZUCKERMAN
Portable Sales Div.
Myers-Sherman Co.
Streator, Illinois

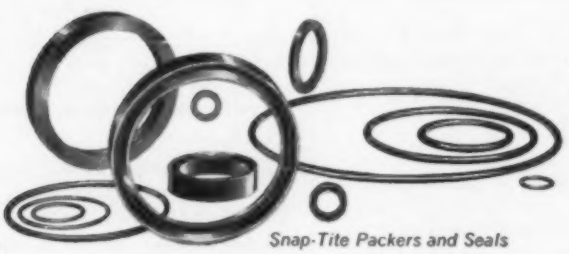
Tear sheets of the article, "High Torque Motor Has Radial Crank Design" have been sent. ▼▼▼

A complete choice of packers and seals permits Snap-Tite quick-disconnect couplings to handle over 600 different fluids! *(some of them mighty tough)*

Whatever fluid you're working with, chances are Snap-Tite couplings can handle it. Because every-one of the thousands of Snap-Tite quick-connect valved couplings comes with a wide choice of rubber packers and seals, selected according to the fluid in use. The right choice, of course, is vital for the seal is the very heart of the coupling.

To assist you in the proper selection of coupling seal material, Snap-Tite, with the assistance of suppliers of synthetic rubber materials, has recently compiled a comprehensive Packer Usage Guide —the first of its kind in the industry.

For the Packer Usage Guide, and for complete information on the correct choice of quick-connect, quick-disconnect couplings for the fluids *you* use, write Snap-Tite, Inc., Union City, Pa.



Snap-Tite Packers and Seals

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UNION CITY, PA.

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K-8120

HYDRAULIC WATCHDOG

POSITIVE AUTOMATIC PRESSURE CONTROL

FOR ANY

HYDRAULIC SYSTEM

FULFLO

ALERT... instant pressure regulation gives complete protection
FAITHFUL... engineered for long, trouble-free service
QUIET... shear-closing action eliminates "chattering"

FULFLO

Whatever your requirement . . . for O.E.M. use or replacement service, there's a dependable FULFLO Oil By-Pass Relief Valve designed just right, built right and priced right too!

STANDARD MODELS

Screw or flange types—to 600 lbs.—for pipe sizes to 3"—steel, cast iron or brass bodies—brass, steel or stainless trim.

SPECIALS

Engineered to your most exacting requirements, for any application, designed to do your particular job to perfection.

Write for Data Book with complete specification and engineering data.

THE FULFLO SPECIALTIES COMPANY, INC. • 415 Fancy Avenue • Blanchester, Ohio

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FLUID POWER FORUM

Each month HYDRAULICS & PNEUMATICS surveys readers for their experiences and opinions in fluid power design.

• ***What improvements would you like to see in fluid power components?***

Precise Motion Required

In the manufacture of semiconductor devices extremely rigid tolerances and continual miniaturization are the watchwords. In designing tooling for many of these devices, we have investigated the possibility of using hydraulic units. We have found, with low pressure operation, that they cannot be made sufficiently sensitive to meet precise motion requirements.

D. E. FELKER
Engineer
Western Electric Co., Inc.
Allentown, Pennsylvania

6000-psi Loading Equipment

Recently, we have been considering 6000-psi systems on some of our woodpulp and log loading devices, but there seems to be a dearth of manufacturers in this line. Consequently, three of our latest prototypes use high volume, 2000-psi systems. Actually, a 6000-psi system on our large loaders would be very desirable. However, there is not much to choose from when searching for components.

THOMAS M. CORSHE
Chief Engineer
Hiabob Hydraulics
Ashland, Wisconsin

Directional/Pressure Control Valve

I need a double solenoid, pilot-operated, pressure-regulating hydraulic valve with a 3-position spring-centered spool. It should

Continued on page 18

another **IMPROVED PRODUCT** *from* Modernair

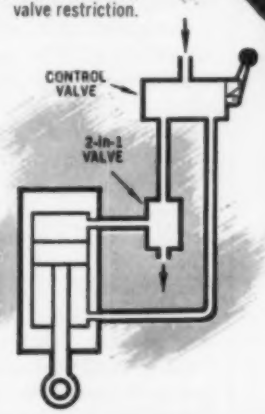
2·IN·1 VALVE

Introduced less than a year ago, this versatile valve has gained such acceptance that production runs now warrant die-casting. The result is a more compact design, improved ruggedness and ease of installation—at no increase in price.

The 2-in-1 operates on pressure differential and its only moving part is its rugged neoprene diaphragm. It is completely self-contained and provides fast, full-flow connection of air from either one of two sources, but not between the sources. It can thus serve two functions:

1.

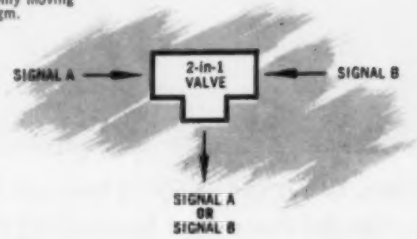
QUICK EXHAUST VALVE ... the instant pressure is cut off by the control valve, the pressure differential from the cylinder or work lifts the diaphragm and releases exhaust air from the cylinder to atmosphere with virtually no restriction. Compact 2-in-1 valve can be mounted directly on or close to cylinder, eliminating line friction and control valve restriction.



Die-cast aluminum bodied 2-in-1 valve operates at air pressures to 200 psi, is only 1¾" in overall diameter, 2¼" long, with ⅜" NPT ports. Only moving part is a Neoprene diaphragm.

2.

DOUBLE CHECK VALVE ... in this function, 2-in-1 valve connects two independent supply or control lines to a common outlet. Ideal for use in two-station control, interlocking and "hold" circuits.



Modernair 2-in-1 valves are currently available in ⅜" port size shown with larger port sizes to come. They have scores of money-saving, problem-solving applications in air control circuits. For complete information, see your phone book yellow pages for your nearest Modernair dealer, or write us.

Modernair **CORPORATION**

400 Preda Street • SAN LEANDRO, CALIFORNIA • Phone: LOckhaven 2-6485
5007 Brookpark Road • CLEVELAND 35, OHIO • Phone: SHadyside 9-6393

MEMBER NATIONAL FLUID POWER ASSOCIATION

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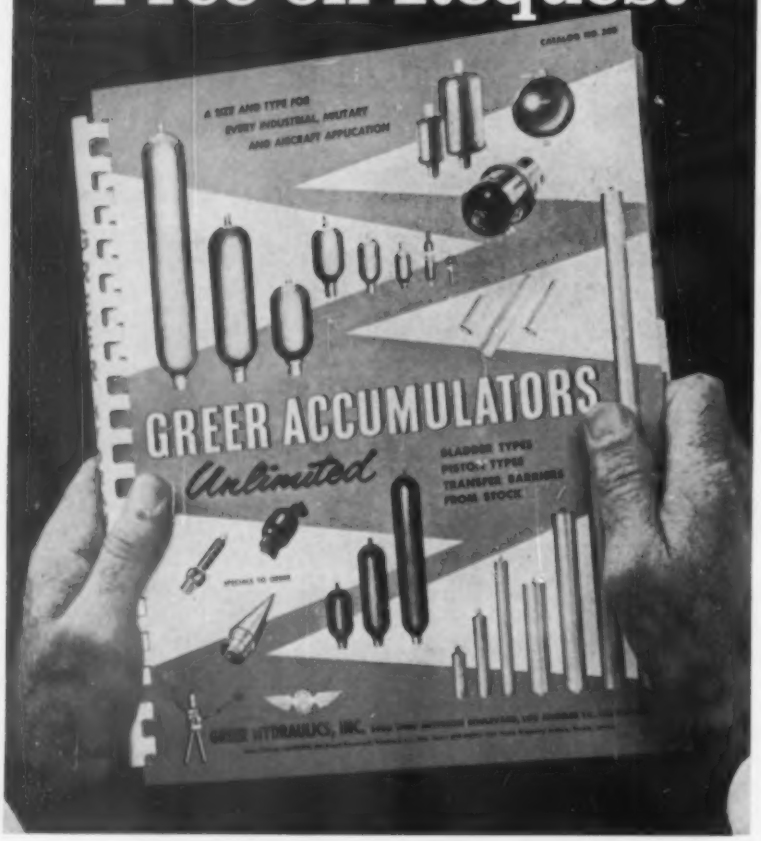
67

FOR DESIGN ENGINEERS:

Valuable Accumulator Handbook-Catalog Free on Request



Circuits, Curves and Complete Technical Information on Bladder-Type and Piston-Type Accumulators Available from Stock

More than 113 pages are devoted exclusively to hydro-pneumatic accumulator principles, uses in hydraulic circuits, designs and specifications in the new Greer "Accumulators Unlimited" handbook-catalog. Complete design information extensively covers: *Bladder Accumulators*—3,000 psi and 6,000 psi series—more than 30 standard off-the-shelf models in sizes from 1½ cubic inches to 10 gallons including transfer barriers; *Piston Accumulators*—nine sizes, 10 cubic inches to 10 gallons, available from stock in a 3,000 psi series, other sizes available to 30 gallons. This valuable "Accumulators Unlimited" handbook-catalog is available to design engineers without obligation. Contact your Greer representative.

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FORUM.

permit setting of a variable high pressure (1000-3000 psi), and a variable low pressure (150-1000 psi) when either solenoid has maintained contact. It should dump directly to reservoir (minimum pressure) when neither solenoid is energized.

I also need a telescoping hydraulic pipe connection with supply and return lines housed in the same unit.

J. BRAAMS
Hydraulic Project Engineer
Aluminium Co. of Canada
Arvid, Quebec, Canada

Low Pressure Hydraulic Design

There is a need for low pressure hydraulic components for the OEM market at prices that do not tend to force the end article out of the competitive market. A multiple stage, hydraulic lift designed by my company required a positive displacement pump in the 5 to 35 gpm range. Many pumps meet these requirements, in fact most surpass them. This excess necessarily increases the cost.

Some time back we built a stationary fork lift to operate in the soaking pit of an atomic energy plant. All parts of the lift operated in 24 feet of water except the hydraulic pump, motor, and controls. The hydraulic system used de-ionized water for hydraulic fluid at the rate of 30 gpm at 350 psi. There are very few off-the-shelf pumps capable of this requirement.

We have since built another multiple stage lift for moving the Polaris missile up and down in the test tank. De-ionized water for hydraulic fluid and stainless cylinders of stainless steel tubing were necessary. Here again, the designer of multiple stage cylinders runs into trouble. To lift loads of 2000 to 4000 pounds, it is necessary to start with a 3 or 4 inch OD tube for the smallest stage and proceed in 1-inch increments to reach the required height. It is necessary to increase diameters in whole inches

Continued on page 20

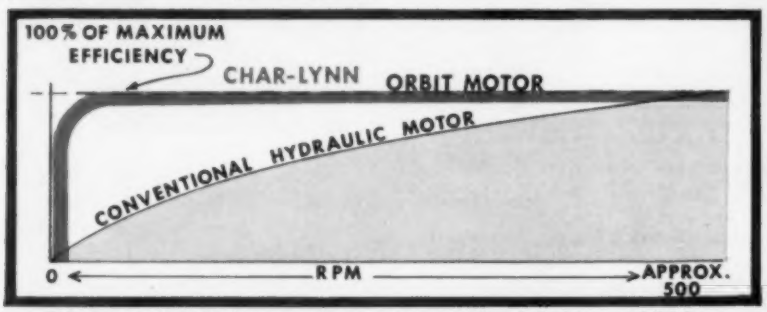
HIGH TORQUE at SLOW SPEED

Patent No. 2,821,171

New Char-Lynn Hydraulic ORBIT MOTORS® deliver Full Torque regardless of speed range

It's Here—A NEW concept in fluid power mechanics has brought about the development of a totally new fluid motor—A *High Torque—Low Speed* motor.

These motors open up complete new areas for design, never before possible. They offer a practical and economical hydraulic solution to the age-old problem of providing High Torque at Low Speeds for constant and variable speed drives—hydrostatic transmissions and remote controls *without* bulky, costly mechanical drives and gear reducers.

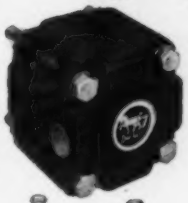


Whereas hydraulic losses make some conventional designs prohibitive at the lower speeds, Char-Lynn ORBIT MOTORS maintain high efficiency over the complete operational range.

- Speeds from 0—800 RPM
- Torques to 3300 inch lbs.
- Starting torque substantially equal to running torque
- Fully reversible — instantaneous starting—stopping
- Only 3 moving parts
- 4 types of mountings available
- 3 port sizes—7 power element selections
- Compact—lightweight
- Eliminates costly and complicated power transmissions
- High volumetric and overall efficiency

complete your HYDRAULIC CIRCUITS with Char-Lynn COMPONENTS

HOLDKONTROL VALVE V-960



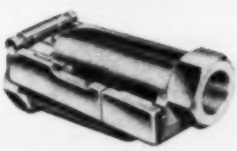
HORSEPOWER PUMP 400

HI-LO POWER PAC PUMP E-600

STROKONTROL CYLINDER C-133

HORSEPOWER CYLINDER C-102

HYDRAULIC FLUID FILTER F-240



HOSE COUPLER H-730

For complete details write Dept. HM Char-Lynn Company • 2843-26th Avenue South, Minneapolis, Minnesota

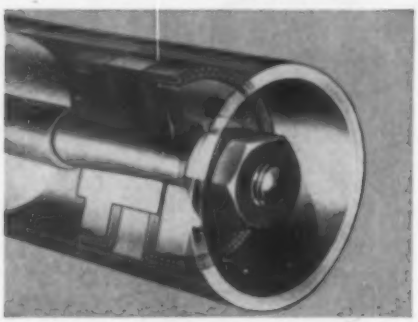
Char-Lynn HYDRAULIC HORSEPOWER PRODUCTS

PUMCUPS

outlast ordinary packings

3 TO 1

- *in hydraulic and pneumatic mechanisms*
- *in reciprocating pumps*



With Darcova Pumcups...regardless of wear, pressure keeps Pumcups hugging cylinder wall.

Operating costs go down and efficiency goes up when Darcova Pumcups go in! Here's why:

- **Pumcups outlast other packings at least 3 to 1, based on actual reports from users**
- **Fluid slippage is virtually eliminated, because Pumcups operate at full efficiency throughout their entire life**
- **Maintenance costs are reduced, because you have fewer replacements, less downtime.**

Available in three textures—hard, medium and soft. Also in regular or nylon composition. Size ranges from ¾" to 20". For *all* the facts on Darcova Pumcups, write for Bulletin 5903.

DARLING VALVE & MANUFACTURING CO.
Williamsport 15, Pa.

DARCOVA
THE ORIGINAL COMPOSITION CUP
TRADE MARK
PUMCUPS

Circle **34** on Reader Service Card

FORUM

to keep packing and gland sizes uniform.

The difficulty is that 5-inch OD stainless is not readily available. As a matter of fact, the length of tubing used in the Polaris lift was shipped from New Jersey to California for this job, causing added expense and loss of time. As we proceed, 6-inch stainless tubing is a stock item with all warehouses. However, 7-inch OD stainless is practically non-existant.

If we change over to the carbon steel tubing, the sizes are available until 11-inch OD tubing is needed. Again, this is non-existant.

In the accompanying picture, the self-propelled lift with the cross boom that mounts an x-ray unit could have had a lower collapsed height had 11-inch OD tubing been available. This is also true of a 70-foot maintenance lift we manufacture. To go beyond 10-inch OD it is necessary to skip the 11-inch size and use 12-inch OD tubing. This requires a special packing gland, and also another drawing for the shop.

The tubing situation is not all dark, however. Welded and drawn-over-mandrel tubing that has been developed recently will solve many hydraulic problems.

HORACE G. GREGORY
Hydraulic Design Engineer
G. W. Galloway Co.
Baldwin Park, California

▼▼▼

KEELAVITE
Hydraulics

ELECTRO HYDRAULIC SERVO VALVES

the key to the successful combination of hydraulics and electronics

The Keelavite electro-hydraulic servo valve consists of a rotary torque motor driving a pilot valve, which provides one stage of hydraulic amplification, to control the position of the second stage piston.

Two sizes of valve are currently available:

Type 5545 giving a flow for a pressure drop of 1000 psi of 25-50 gpm...and

Type 5572 giving a flow for a pressure drop of 1000 psi at 100 gpm.

The first stage consists of a nominally zero lapped 3-way valve, which is driven against springs by a rotary torque motor. Balanced windings are fitted to the torque motor. These may be either low or high impedance. An inductive rotary pick-up, also driven by the torque motor, is used to close a feed-back loop around the pilot valve.

The second stage consists of a conventional piston type valve, which may be fitted with either a 4-way or 5-way piston. The body is made of close grain cast iron. Zero, under and overlapped pistons are available. Internal leakage and flow linearity with deflection are both dependent on piston lap.

THE RECOGNISED AUTHORITY ON HYDRAULIC POWER TRANSMISSION

KEELAVITE COMPLETE HYDRAULICS
- a complete range of units
- thirty years of hydraulic experience
- and a service that means success

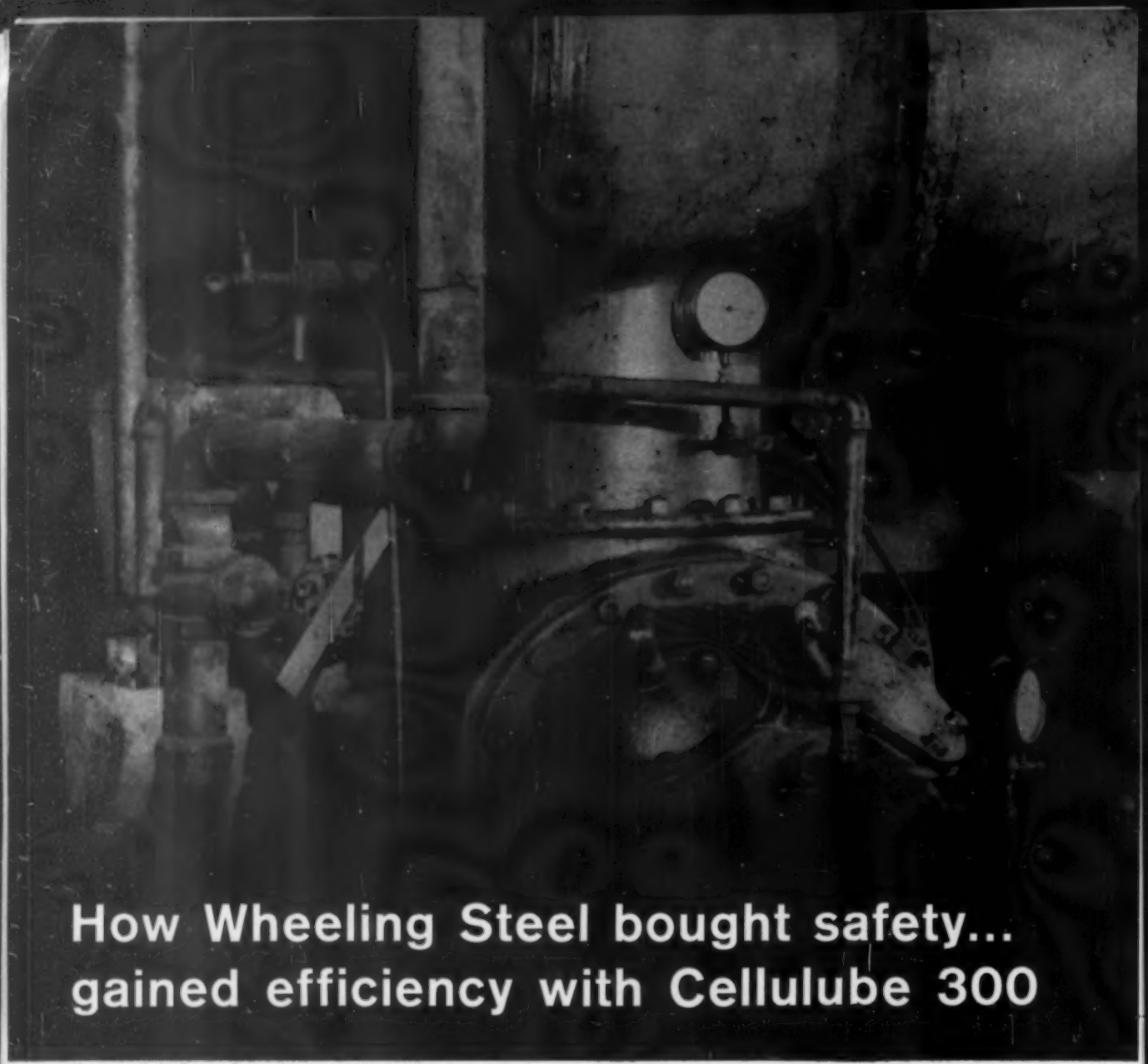
For full details write to

KEELAVITE
Hydraulics

KEELAVITE HYDRAULICS LTD

ALLESLEY, COVENTRY **TEL: MERIDEN 441**

European Representative—Mr. T. P. Keeling, Keelavite Hydraulics, Ltd., Pieter de Hoochstraat 17, Rotterdam 6, Holland



How Wheeling Steel bought safety... gained efficiency with Cellulube 300

Mr. Kenneth N. Bundy, Superintendent of Utilities Department, Steubenville Works, Wheeling Steel Corporation is responsible for the safe and efficient operation of power house equipment. Air compressor lubricant is fire-resistant Cellulube 300.

Two of three 100 psi. air compressors in power house at Wheeling Steel. Not a single air-compressor fire has occurred at this installation since Celanese fire-resistant Cellulube 300 has been used as the lubricant.

Compressor fires were troublesome before Celanese Cellulube was used in three dual stage, 100 psi. air compressors in the power house of Wheeling Steel's Steubenville Works.

To stop this fire problem, Celanese recommended Cellulube 300. And, since use of this fire-resistant fluid was initiated more than five years ago, there has not been a single fire in any of the compressors! What's more, substantial savings have been gained through reduction in maintenance.

Celanese Cellulubes, available in six controlled viscosities, prevent build-up of hard car-

bon deposits. Cleaner operation eliminates the need for cleaning compressor auxiliaries and greatly reduces frequency of valve cleaning.

Cellulubes give overall protection against wear comparable to that of premium petroleum oils.

Doesn't it make sense to investigate what fire-resistant Cellulubes can do for you in terms of both safety and efficiency? The coupon will bring you complete details. Celanese Chemical Company, 522 Fifth Avenue, New York 36, N. Y.

Celanese® Cellulube®

Celanese Chemical Company is a Division of Celanese Corporation of America
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co. Inc., and Pan Amcel Co., Inc., 522 Fifth Avenue, New York 36

Celanese
CHEMICAL COMPANY

CELANESE CHEMICAL COMPANY
Dept. 588-L, 522 Fifth Avenue, New York 36, N. Y.

Rush data on Cellulubes.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

My application for Cellulubes is_____

_____

Circle **24** on Reader **Service Card**

FLUID POWER AT WORK

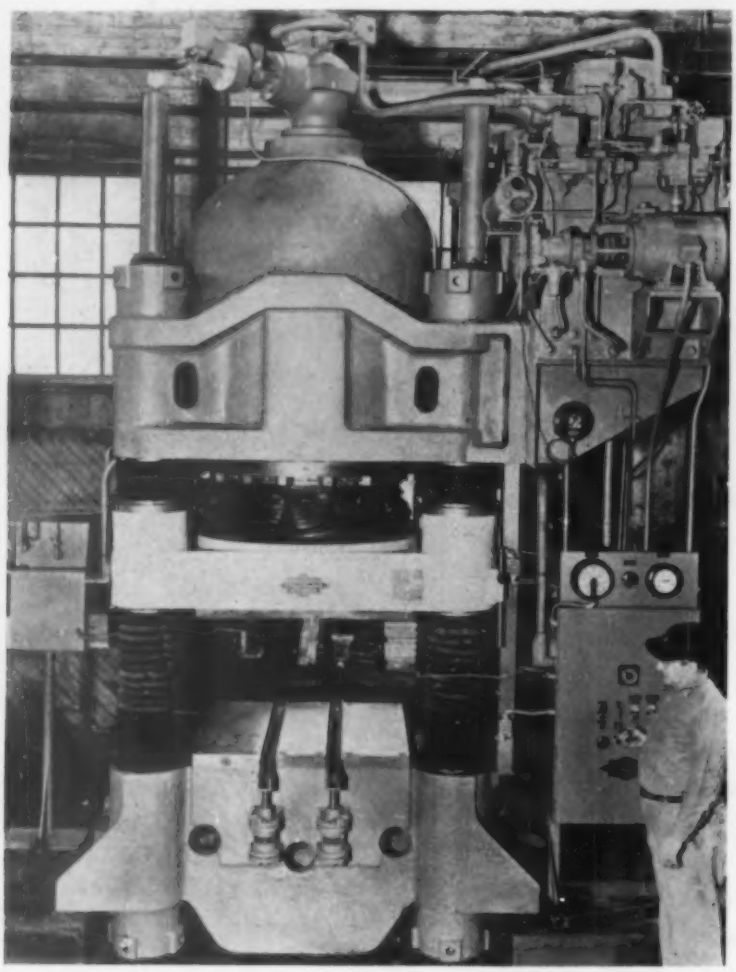
keeping up with design, application, methods

Press Has Interlocking Controls

This hydraulic press for grinding wheels can be operated at different press strokes, tonnages, and daylight openings from two different stations. The 1600-ton press, manufactured by Birdsboro Corp., Hydraulic Div., Reading, Pa., is a single-action, down-movement, four-column machine with interlocking controls. The controls allow independent operation at each station at loads varying from 200 to 1600 tons.

Each operator has a setup button which locks up the other station, and prevents the other operator from taking control of the press. An emergency return button at each station lets either operator stop the press in an emergency, and return it automatically to its fully open position.

Press working area is 41 x 41 inches. Maximum daylight is 33 in. and maximum working stroke is 29 in. All exposed, machined surfaces such as rams, columns, and moving platen guides are protected with neoprene—impregnated, accordion type, zippered closure boots. The hydraulic pumping unit is at the top of the self-contained press.



FPS News

Annual Meeting Stresses Education

CHICAGO—With education a major goal of the Fluid Power Society, most of the annual meeting in October was devoted to a study of present educational programs and techniques. Six papers described present courses in high schools and colleges, and indicated future needs and planning for fluid power training. Speaking on fluid power at the high school level, William

The Fluid Power Society has been formed to further the development and use of fluid power. Membership information is available from headquarters at 5595 N. Hollywood Ave., Milwaukee 17, Wisc.

Continued on page 26

Circle 86 →

the precision air valve

with the stainless steel stomach!

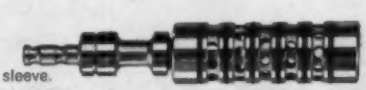
Air lines get dirty even in the best of plants. Dirt stops most valves, and production. But a Numatics valve keeps on working.

We don't say it's impossible to jam a Numatics valve but you can't hurt it with dirt. Why? The hardened, stainless steel, lapped spool and sleeve—unique in the industry. No resilient seals to get chewed up, or seize after long shutdowns. Working smoothly with millionths of an inch clearance, the stainless sleeve and spool—with razor sharp lands—will digest a diet of cast iron, aluminum, and steel chips, and foundry sand.

A Numatics valve will keep on working (even improve with service) under conditions that would stop an ordinary packed valve dead.

Any wonder we call Numatics valves the most reliable in the industry?

Buy Numatics—and relax.



The lapped spool and sleeve.
It works, and works, and works.

NUMATICS, Inc.

Highland, Michigan

NEW NEW NEW NEW NEW NEW

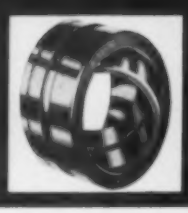
NOW! 1½ TONS PER SQUARE INCH CONTINUOUS RATING

**Tested at 2½ tons per square inch*

Pathon 3000 PSI HYDRAULIC CYLINDERS

The New Pathon Series 3H Hydraulic Cylinders are not an adaptation or modification of existing models, but specially designed 3000 P.S.I. Cylinders, continuous service. The 3H Series is available in a wide range of bore sizes and standard mounting types. Like all other Pathon Cylinders, the 3H Series features:

- Single screw thread head attaching method
- Increased strength and fatigue life
- Low Stress Concentration
- Compactness



Illustrated, Model 3H 33 incorporating spherical bearing at the pin connection.

FOR ADDITIONAL INFORMATION
WRITE—WIRE—PHONE TODAY

Pathon MANUFACTURING COMPANY
3823 PACIFIC AVE., CINCINNATI 12, OHIO

FLUID OPERATED AND CONTROL EQUIPMENT

Circle **91** on Reader Service Card

FLUID POWER AT WORK

Gayde described a course at Fitzgerald High School in Warren, Michigan. This includes a study of fundamental fluid power mathematics, components, circuits, design, and assembly on a test stand. Equipment for laboratory work was purchased with a $10,000 grant through the National Defense Education Act. In promoting a similar course at other general high schools, Gayde indicated that the American Industrial Arts Association has shown interest.

A new industrial hydraulics laboratory which cost about $60,000 is part of a course at Cass Technical High School in Detroit. John Blaschek who teaches the course outlined its coverage and indicated the limitations which a shortage of trained teachers puts on fluid power education.

Cass Apprentice School in Detroit has a course in hydraulics and pneumatics given in three sections for tool and die apprentices. Basic theory covers terminology, mathematics, symbols, component principles, and basic circuits. Circuitry develops use of flow control valves, principle of pressure compensation, and system operation.

At the college level, 22 institutions out of 176 surveyed have full fluid power courses. Dudley Pease of Dynex Co. emphasized the problems of fluid power education: a shortage of teachers and comprehensive tests, the need for research scholarships, closer cooperation between industry and colleges. He reviewed the fluid power program offered at Milwaukee School of Engineering (H&P Oct. '61) where six courses are being taught.

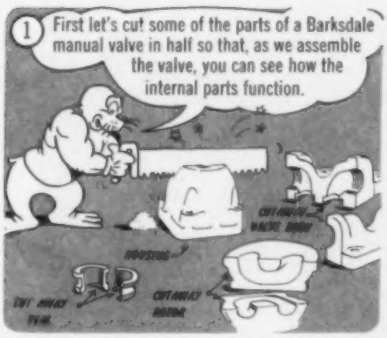
House of Delegates—Morning session of the meeting was attended by delegates appointed by chapters throughout the U. S. and Canada.

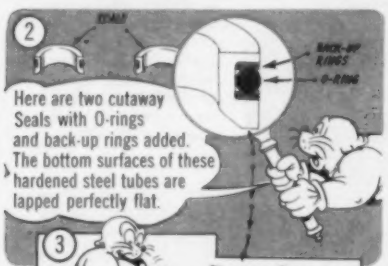
A nominating committee was chosen to select additional members of the Board of Directors. The committee is composed of Walter Woodard, Cleveland, Jack Ogle, Seattle, and Bruce French, Toronto.

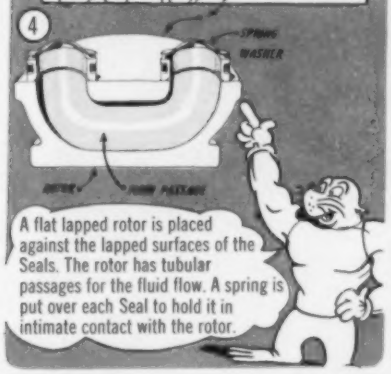
The patented 'Shear-Seal' principle

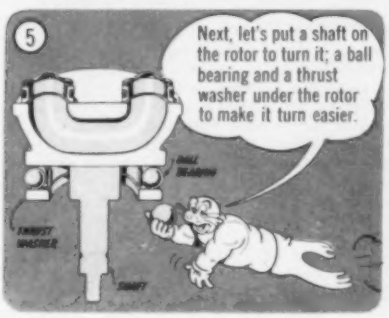
AS EXPLAINED BY...

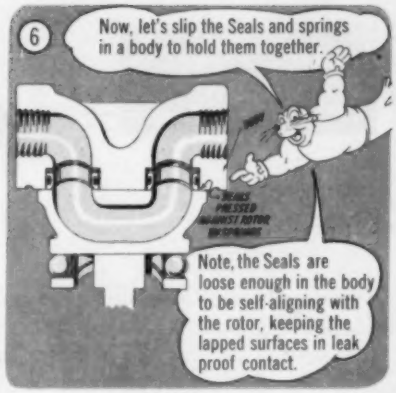
SUPER SEAL

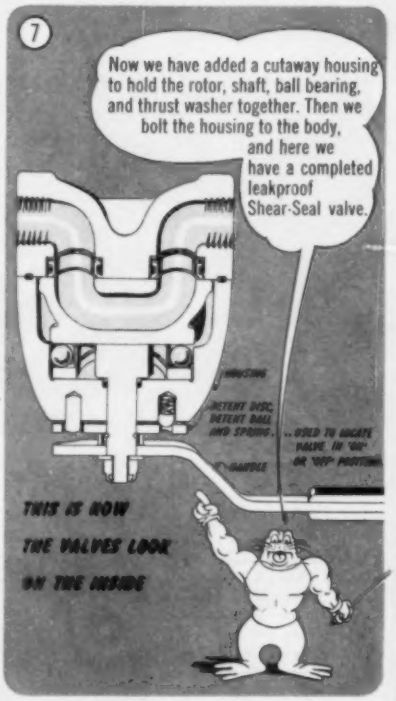

1
First let's cut some of the parts of a Barksdale manual valve in half so that, as we assemble the valve, you can see how the internal parts function.
HOUSING
CUTAWAY SEAL
CUT AWAY VALVE BODY
CUT AWAY ROTOR

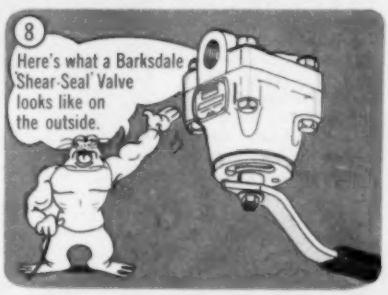

2
SEAL
BACK-UP RINGS
O-RING
Here are two cutaway Seals with O-rings and back-up rings added. The bottom surfaces of these hardened steel tubes are lapped perfectly flat.

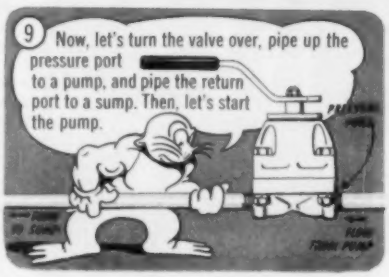

4
SPRING WASHER
ROTOR
FLOW PASSAGE
A flat lapped rotor is placed against the lapped surfaces of the Seals. The rotor has tubular passages for the fluid flow. A spring is put over each Seal to hold it in intimate contact with the rotor.

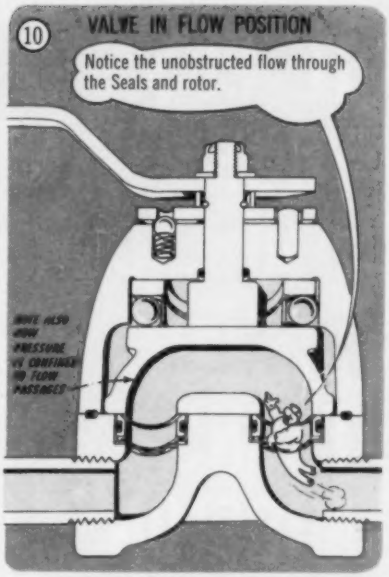

5
Next, let's put a shaft on the rotor to turn it; a ball bearing and a thrust washer under the rotor to make it turn easier.
BALL BEARING
THRUST WASHER
SHAFT


6
Now, let's slip the Seals and springs in a body to hold them together.
SEALS PRESSED AGAINST ROTOR BY SPRING
Note, the Seals are loose enough in the body to be self-aligning with the rotor, keeping the lapped surfaces in leak proof contact.


7
Now we have added a cutaway housing to hold the rotor, shaft, ball bearing, and thrust washer together. Then we bolt the housing to the body, and here we have a completed leakproof Shear-Seal valve.
HOUSING
DETENT DISC, DETENT BALL AND SPRING
... USED TO LOCATE VALVE IN "ON" OR "OFF" POSITION
HANDLE
THIS IS HOW THE VALVES LOOK ON THE INSIDE




9
Now, let's turn the valve over, pipe up the pressure port to a pump, and pipe the return port to a sump. Then, let's start the pump.
PRESSURE PORT
TO SUMP
FLOW FROM PUMP


10
VALVE IN FLOW POSITION
Notice the unobstructed flow through the Seals and rotor.
NOTE ALSO HOW PRESSURE IS CONFINED TO FLOW PASSAGES

11
Now, let's move the handle – shear the flow and see how the 'Shear-Seal' Valve gives its leakproof service.
THESE ROTOR AND SEAL ARE BOTH LAPPED OPTICALLY FLAT AND HELD IN INITIAL CONTACT BY A SPRING. FLUID CAN'T GET BY AND LEAKAGE IS STOPPED
HANDLE IN DASHED POSITION
PRESSURE GETS IN BACK OF SEAL AND FORCES IT AGAINST ROTOR

12
IN SUMMARY
'SHEAR-SEAL' VALVES
have long life and are maintenance-free because: as the Seal and rotor slide back and forth over each other with use, they keep lapping themselves and seal even tighter.

CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

TO PUT YOUR HYDRAULIC POWER TRANS-MISSION IDEAS TO WORK:

P3 SERIES HYDRAULIC GEAR PUMP
Capacities 8.0 to 21.0 GPM at 2000 RPM and 2000 PSI
Displacement 1.0 to 2.7 cu. in.
Speeds to 3000 RPM
Operating Pressure 2000 PSI

Controlled pressure loading* is the refinement Wooster engineers offer to design engineers. Whether the pump is operating at high or low pressure, high or low speed, the loading force is always directly proportional to the unloading force, lengthening pump life by preventing undue loads on bearing faces and journals.

Soon to be announced: New 3D Series Wooster Hydraulic Directional Control Valve.

*Patent Nos. 2430622, 2823615, 2894502 OTHER PATENTS APPLIED FOR

WOOSTER DIVISION B-W

BORG-WARNER CORPORATION
WOOSTER, OHIO

Circle 121 on Reader Service Card

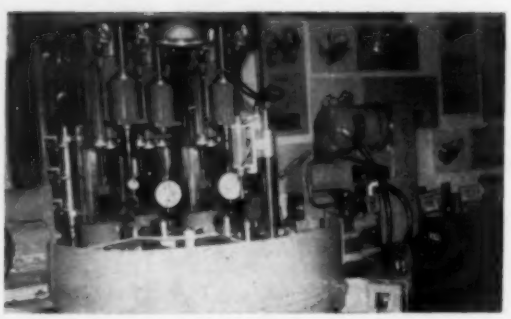
FLUID POWER AT WORK

ASTME Show Features Numerical

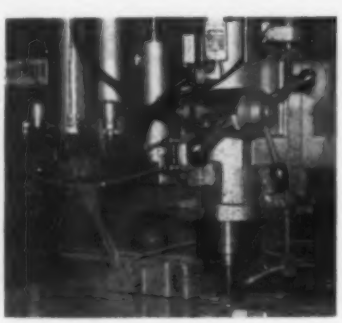
• By HENRY LEFER,

Two trends were notable at the recent exposition of the American Society of Tool & Manufacturing Engineers in New York's Coliseum. One was the wide use of fluid power for muscle, control, and precision movement. The other was the increased emphasis on numerical control of machine tools and other metal fabricating equipment.

A HYDRAULIC PUMP drives the index cam on this transfer machine. It is completely self-contained and standardized for use in production, assembly, or testing systems. Made by Standard Tool & Manufacturing Co., Lyndhurst, N. J., the machine has a speed of 6000 indexes per hour with a location accuracy of .003 in.



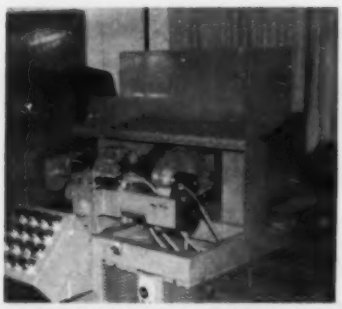
HYDRAULICALLY CONTROLLED, way-type power units move precision high-speed spindles on this multiple secondary operation machine. Made by Standard Tool & Mfg. Co. it simultaneously performs operations formerly done on hand screw machines, drill presses, light milling machines, and threading and tapping machines. Spindle strokes are up to 3 in. with accuracy of .0005 in.



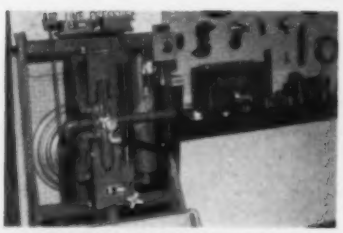
AIR CYLINDERS extend and retract the stylus and cutting spindle on this automatic profiler. Automatic programming is done with electronic switches, and stylus position is detected by magnetic-induction and amplified to the servo positioners. Made by the New England Machine & Tool Co., the profiler has feed rates up to 80 ipm in any direction.

Fluid Power and Control

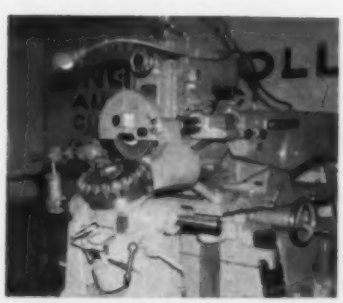
Eastern Editor



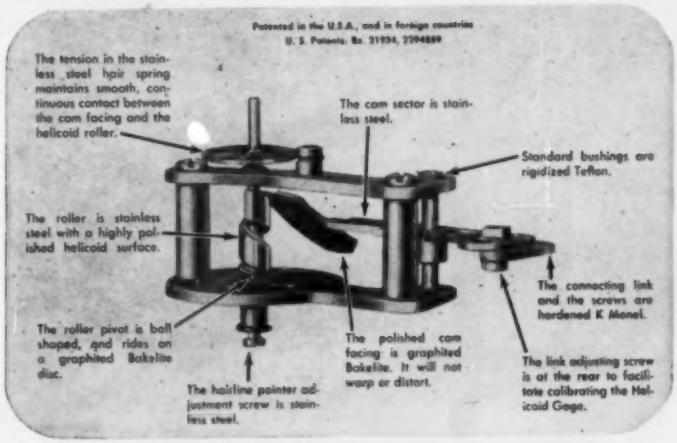
DOUBLE-END TUBE FINISHING MACHINE is all hydraulically operated. It has a capacity of 3000 tube ends per hour. Made by Pines Engineering Co., Aurora, Ill., it deburrs, chamfers, and faces both ends. The hydraulic system moves the tubes into cutting position, clamps the dogs, and extends and retracts the cutting spindles.



HYDRAULIC PIERCING FIXTURE operates on plant compressed air. The fixtures are made by Die-Draulic Grip, Inc., Grand Rapids, and can be used for punching, trimming, clamping, and other hydraulic operations.



CUTTER GRINDER automatically grinds milling machine cutters from 4 to 20-in. diameter. A tracer finger follows a control cam and signals the hydraulic system for machine movement. Made by Ingersoll Milling Machine Co., Rockford, Ill., the machine can reproduce its own control cams from a milling cutter.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2394889
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

Distributed in Canada by
Upton, Bradeen & James, Ltd.
Quebec, Montreal, Ottawa, Toronto, Hamilton, Windsor, Winnipeg, Edmonton, Vancouver

WRITE for details

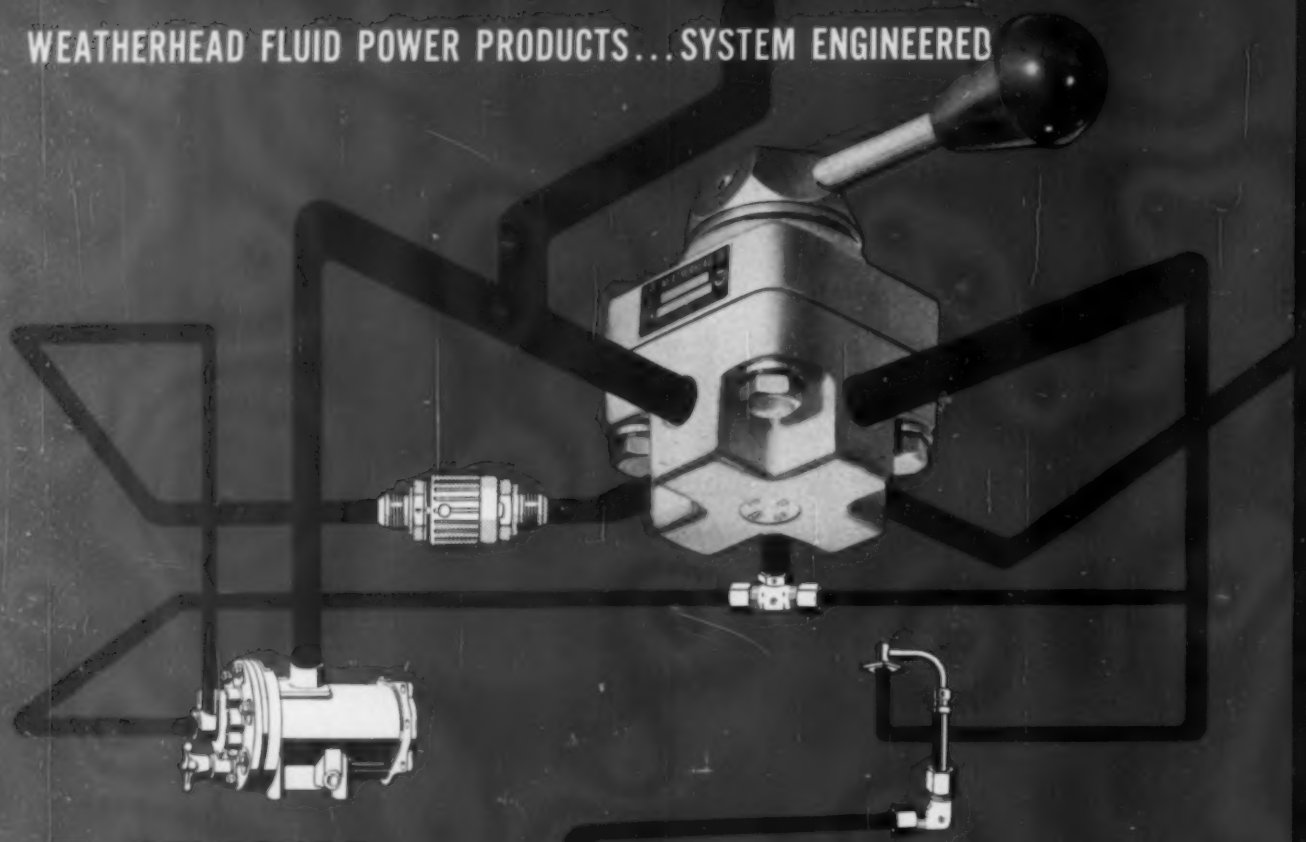
Ask for Catalog DH-65

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-H Connecticut Ave., Bridgeport 2, Conn.

Circle **56** on Reader Service Card

WEATHERHEAD FLUID POWER PRODUCTS...SYSTEM ENGINEERED



SELECTOR CONTROL VALVES STANDARDIZED FOR ECONOMY... ENGINEERED FOR VERSATILITY

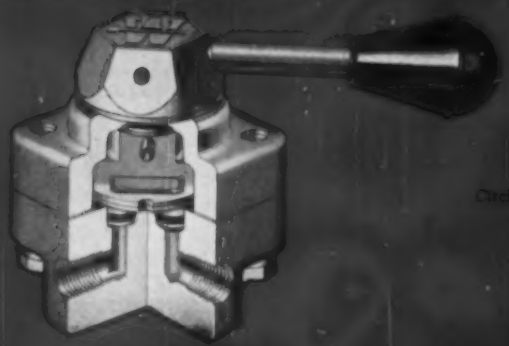
Unmatched economy is achieved by standardizing on a 4-way design, adaptable to 2 or 3-way selection. Greater versatility is provided because this advanced control monitors hydraulic or pneumatic flow pressures ranging from zero to 3000 psi.

These outstanding capabilities eliminate need for additional spare parts on intermediate pressure models . . . assure availability from distributor stock . . . simplify varied application needs over wide pressure range.

Weatherhead selector control valves offer: safe, smooth operation ■ positive sealing ■ spring centered, or detent position handles ■ horizontal or vertical ports ■ panel mounting or flexibility within the system.

Contact your nearby Weatherhead distributor or write direct for latest brochure.

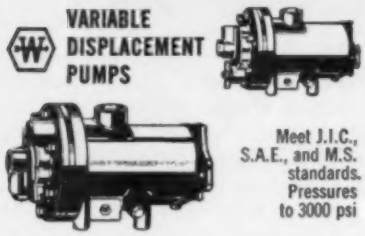
THE WEATHERHEAD COMPANY
CLEVELAND 8, OHIO



Circle 113 on Reader Service Card

WEATHERHEAD
HYDRAULIC POWER
Components

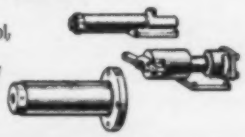
VARIABLE DISPLACEMENT PUMPS



Meet J.I.C., S.A.E., and M.S. standards. Pressures to 3000 psi

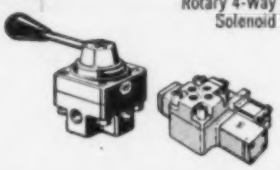
PUMP CONTROLS

Pressure Control, Automatic (Constant) Flow Control, Manual Displacement Control



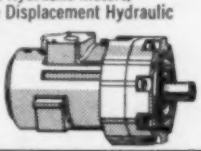
DIRECTIONAL CONTROLS

Rotary 4-Way Valves
Solenoid Valves



HYDRAULIC DRIVES

Fixed Displacement Hydraulic Motors, Reversible Variable Displacement Hydraulic Motors (Integrated Torque and Speed Control)

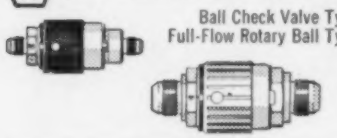


HIGH PRESSURE HOSE AND FITTINGS

Swaged, Crimped, and Field-Attachable Flexible Hose Ends.
Flared and Flareless Tube (Pipe) Fittings.
Integral Check Valves

SELF-SEALING COUPLINGS

Ball Check Valve Type
Full-Flow Rotary Ball Type



THE WEATHERHEAD CO.
300 EAST 131 ST. • CLEVELAND 8, OHIO
Distributors in all major markets

Circle **114** on Reader Service Card

FLUID POWER AT WORK

MSOE Seminar On Hydrostatic Transmissions

MILWAUKEE—Hydrostatic transmissions were analyzed and discussed during a one-day seminar held at the Milwaukee School of Engineering last September. Eighty five manufacturers and users attended the sessions where theory and applications of hydrostatic transmissions were presented.

• **Types of Transmissions**—Russ Henke, Director of Research, Racine Hydraulics & Machinery, reviewed differences between hydrostatic and other transmissions also using fluids.

Henke emphasized the prime differences between hydrostatic, hydrokinetic, hydromechanical and slip-type transmissions. Concentrating on hydrostatic transmissions, he listed their major requirements, advantages and disadvantages. He went on to discuss the various arrangements of fixed and variable displacement pumps and motors that can be used, stressing operating characteristics and advantages of each combination.

• **Ideal Hydrostatic Transmission**—Warren E. Wilson, Chairman of the Department of Engineering, Harvey Mudd College, Clarement, California, outlined the mathematical considerations for an ideal transmission: one that experiences no mechanical or energy losses.

Wilson derived equations for straight hydrostatic transmissions and differential transmissions with either split-torque or split-speed characteristics. He indicated that a further development of the hydrostatic transmission was the introduction of a planetary gear train into the transmission circuit. He then described the kinematics, dynamics, and mechanics of planetary transmissions and compared their operating and performance characteristics with those of differential transmissions.

• **Mobile Equipment Applications**—John F. Swift, Research Engineer, International Harvester Co., Chicago, outlined some of the advantages of hydrostatic transmissions in mobile equipment.

- Continuously variable power
- Engine runs at optimum conditions
- Greater mobility and maneuverability
- Higher efficiency
- More work per day
- Lower fuel costs.

New transmissions will have to compete with existing ones, in such areas as size, weight, initial cost, and maintenance expenditure.

• **Hydrostatic vs. Hydrodynamic Transmissions**—Wesley R. Master, Director of Engineering, Dynex Co., emphasized the differences between these transmissions. Hydrostatic transmissions have these advantages and features:

- Use positive displacement units
- Do not tend to creep
- Fully reversible
- Substantially constant torque available over full speed range
- Direct braking
- Constant speed at various loads

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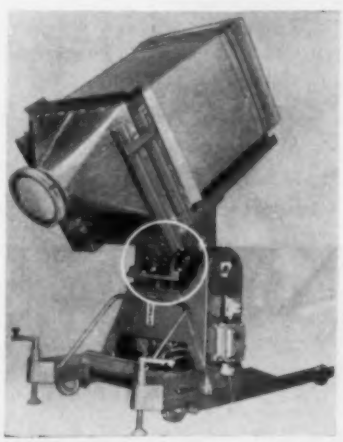


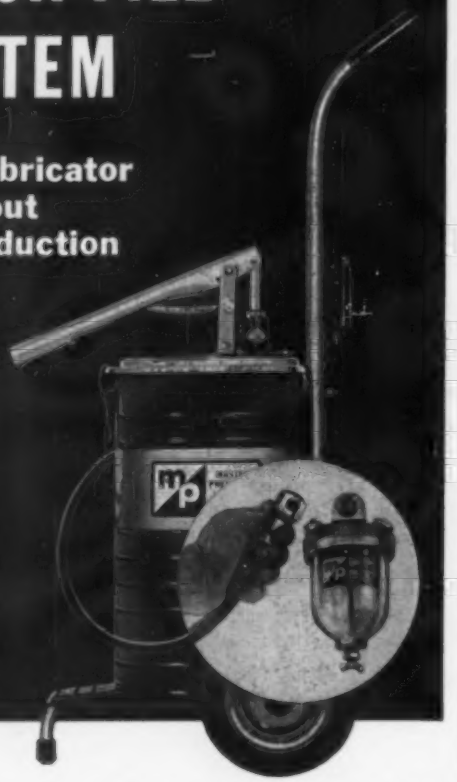
PORTABLE DUMPER, manufactured by Uhrden, Inc., Dennison, Ohio, uses a rotary actuator to turn over 2000-lb cartons. The rotary actuator, manufactured by Ex-Cell-O Corp., is controlled by a 4-way manual valve. A dual holding valve is connected across the lines to prevent unbalanced loads from running ahead of oil supply.

NOW Cut Maintenance Costs!

QUICK-FILL SYSTEM

Fill any airline lubricator in seconds without interrupting production

- EFFICIENT: Establishes a systematic lubricator refill procedure.
- FAST: Eliminates shutting off air pressure.
- CONVENIENT: No filler caps to remove.
- ADAPTABLE: Can be used on any make lubricator.
- SERVICEABLE: Eases filling of hard-to-reach lubricators.
- SAFE: Eliminates the use of ladders.



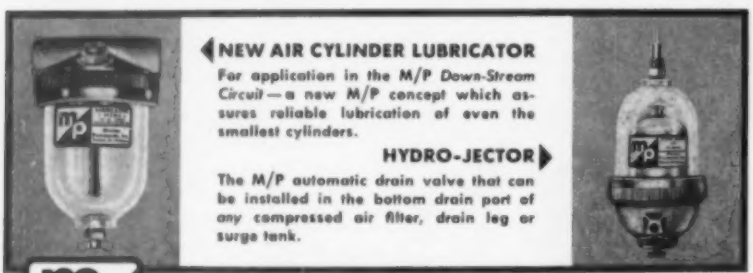
HOW IT OPERATES:

To fill lubricator, the coupler is slipped onto Q-Cap and oil is pumped through the hose. When lubricator is filled, the coupler is removed and the operation is complete . . . in a matter of seconds . . . without loss of air or oil! M/P *QUICK-FILL SYSTEM* equipment includes: pressure fill Q-*Caps*, a *Hook-Tite Coupler*, a flexible wire-braid hose assembly, and a high volume oil pump.

HOW IT CUTS COSTS:

Using M/P *QUICK-FILL*, one man can fill hundreds of airline lubricators in a few hours with no production "down-time". The time and labor saved means reduced costs . . . in maintenance and production.

Contact your local representative or M/P for a detailed brochure.



NEW AIR CYLINDER LUBRICATOR

For application in the M/P *Down-Stream Circuit*—a new M/P concept which assures reliable lubrication of even the smallest cylinders.

HYDRO-JECTOR

The M/P automatic drain valve that can be installed in the bottom drain port of any compressed air filter, drain leg or surge tank.

MASTER PNEUMATIC, INC.

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FLUID POWER AT WORK

Hydrostatic transmissions produce output energy through fluid pressure. Output torque is available at all speeds. A 60-1 speed ratio is practical (50-3000 rpm), and the input and output can be coupled remotely or directly. Positive control.

Hydrodynamic transmissions produce their output energy through a change in fluid velocity. They have no output torque at low input speeds. Speed ratio is approximately 6-1. Input and output are directly coupled, and the transmission offers only limited control.

Master also outlined the progress made in standard split-flow hydraulic transmissions, integrating fixed, variable, and split-flow components.

Illustrating actual design techniques with hydrostatic transmissions, William H. Thompson, of Dynex, described the design of an Army amphibious vehicle for ferrying equipment and forming a bridge.

Polyethylene Envelopes Keep Oil Off Tags

Shipping invoices on outgoing orders at the Tubular Products Division of the Babcock & Wilcox Co., Beaver Falls, Pa., are

wrapped in polyethylene envelopes to protect them against dirt and soilage. This tagging method is convenient as it is virtually oil-proof and keeps the invoices clean after tube bundles have been dipped in oil for protection in transit.

Circle 102 →

SKINNER provides
custom flexibility
in standard
solenoid valves
SKINNER
ELECTRIC VALVES
IN
OUT
CYL.
UL

Versatile, top quality V5, X5 line offers wide range of options

Skinner's two-way and three-way V5, X5 series of solenoid valves has earned the description—"The Universal Line." With more than 100,000 variations possible, V5, X5 valves are available for every conceivable application. And top quality is emphasized with bubbletight sealing, and stainless steel body, plunger and sleeve assembly. Precision machining, unique welding techniques, specially designed and developed machinery and manufacturing methods are all used by Skinner to produce the best valves made. These valves are small, yet handle operating pressures as high as 3000 psi. They accommodate all media that do not corrode stainless steel. And no other solenoid valves offer so many optional features. Check the following options.

FLOW CONTROL

Precise, accurate control of media flow is possible with all Skinner V5, X5 valves. Both two-way and three-way valves are available with adjustable flow in the main stream, and with manual override. Two-way valves are also available with adjustable bypass. Exhaust flow can be controlled in three-way valves.

ELECTRICAL HOUSINGS

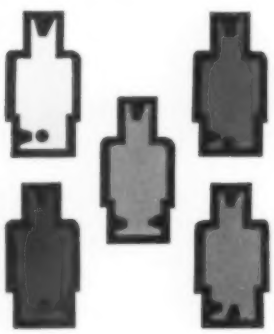
Skinner offers an electrical housing for any application. Some of the most common are:

- standard ½" NPT conduit
- grommet outlet
- single or double automotive terminals
- JIC housings with integral junction box
- AN connector for military applications
- strain relief connector for quick disconnect

All housings are steel, plated for wear and appearance, and can be rotated 360° for easy installation.

PORTING

Restrictions of installation or application, and mounting are minimized because Skinner provides a wide variety of port location options. V5, X5 valves are available with ports at right or left angles, on bottom, top, and sides for virtually all combinations of flow.



MOUNTING

Skinner V5, X5 valves are provided with tapped holes for normal mounting, with mounting brackets for panel or other surface, or with flange for direct mounting without threaded pipe connections.

The Skinner V5, X5 series of two-way and three-way solenoid valves provides top quality design with orifices from 1/32" to 3/16" diameter, normally open, normally closed, dual purpose, directional control and multi-purpose, in standard and explosion-proof construction. Also included in this line is a three-way quick-exhaust type which is designed with an additional port to exhaust cylinders 4 times faster than standard types.

COILS

Skinner V5, X5 valves are available with coils of many types for most DC and AC voltages at 25, 50 and 60 cycle frequencies. Whether your requirements are for continuous or intermittent performance, in tropical, high moisture or high temperature environments, or for dual voltage, Skinner UL approved coils are available with leads of several types and lengths.

• • •

Typical applications—machine tools, cylinder control, instrumentation and automation of all kinds, laundry equipment, aircraft and missiles, etc. For catalogs and complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed internationally.

SKINNER ELECTRIC VALVES ®

THE CREST OF QUALITY

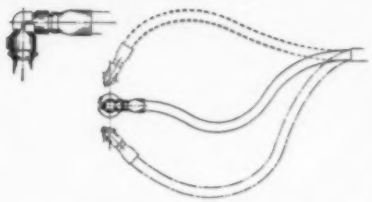
SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.

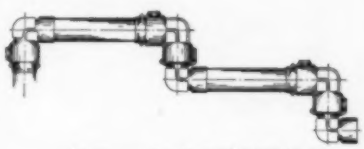
HERE ARE 3 COMMON LINE DESIGN PROBLEMS CHIKSAN SWIVEL JOINTS CAN HELP YOU SOLVE

1 **Shorten hose radii, reduce torsional stress.**



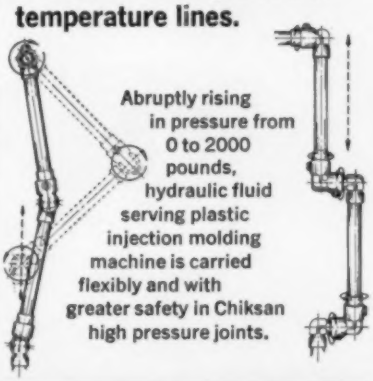
Flexible head on this lens grinder is hydraulically powered. Joints shorten required hose lengths. Hose would otherwise need suspension to keep out of way.

2 **Predetermined flex of piping between two or more points.**

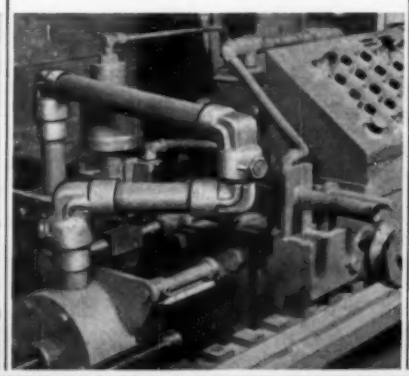


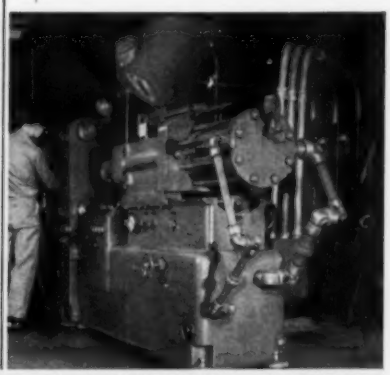
Pressure testing of pipe is nearly automatic as hydraulically driven supply heads close on pipe ends. Dog-leg jointed pipe moves back and forth continuously, safely.

3 **Achieve maximum safety of flexible high pressure, temperature lines.**



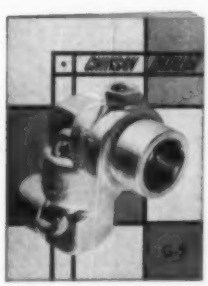
Abruptly rising in pressure from 0 to 2000 pounds, hydraulic fluid serving plastic injection molding machine is carried flexibly and with greater safety in Chiksan high pressure joints.





Studied consideration will quickly show that Chiksan swivel joints have numerous applications. Whenever you have a piping situation where movement is required, the benefits of swivel joints should be weighed. As illustrated above, Chiksan swivel joints have great versatility. They give added life and adaptability to rubber hose. They give metal lines a rubber-like flexibility. They help relieve stresses imposed by expansion, vibration or misalignment. Chiksan swivel joints, with their full 360° rotation and high service life, quickly pay for themselves by minimizing hose failures, eliminating costly line failures, fluid loss and downtime. Chiksan swivel joints have a wide range of pressure and temperature ratings to meet most industrial applications. There is a nearby experienced representative who will call, analyze your requirement and make specific recommendations. Write today for his name.

#61-64



fmc **CHIKSAN COMPANY** • 330 NORTH BREA BLVD., BREA, CALIFORNIA

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

Please send me a copy of your catalog and the name of your nearest representative.

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fabric impregnated V-RING sets

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HOMOGENEOUS CUP PACKINGS

FLANGE PACKINGS

DOUBLE LIP WIPERS

PHENOLIC ADAPTORS

V-RING SETS

HOMOGENEOUS "U" PACKINGS

"O" RINGS

...IN ELASTOMERS TO SUIT THE APPLICATION....

Periflex has assumed a leading position in packing design and development. Latest contribution to better reciprocating sealing techniques: Famous Periflex lip-action V-ring sets are now made available

Left—Periflex pressure rings preload the packing. Give lip-action that seals at all pressures with minimum interference. Right—Extrusion-proof "phenol-fab" adapters. Reduce cavity machining costs.

in a variety of elastomers, assuring best performance for a wide range of hydraulic media. Write for reprint of the informative article from Hydraulics & Pneumatics magazine, "Elastomers For Hydraulic Packings", written by our Technical Director.

Periflex • Inc.

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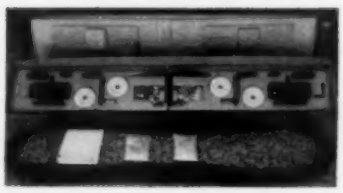
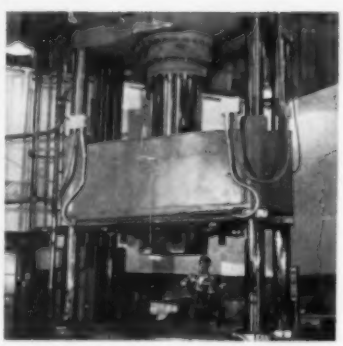
FLUID POWER AT WORK

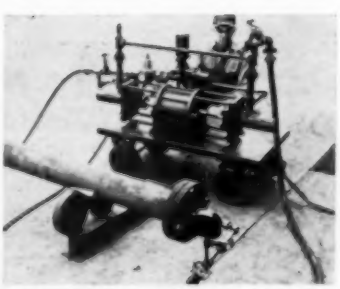


TWO HYDRAULIC HOSE adapter kits are now available as off-the-shelf items from Clark Equipment Co. to simplify field installation of fork truck attachments on Clarklift gas and electric trucks. Kits include hose, hose end fittings, brackets, sheaves and guide rods necessary to make a complete connection between the auxiliary valve and terminal point on a truck's fork carriage.

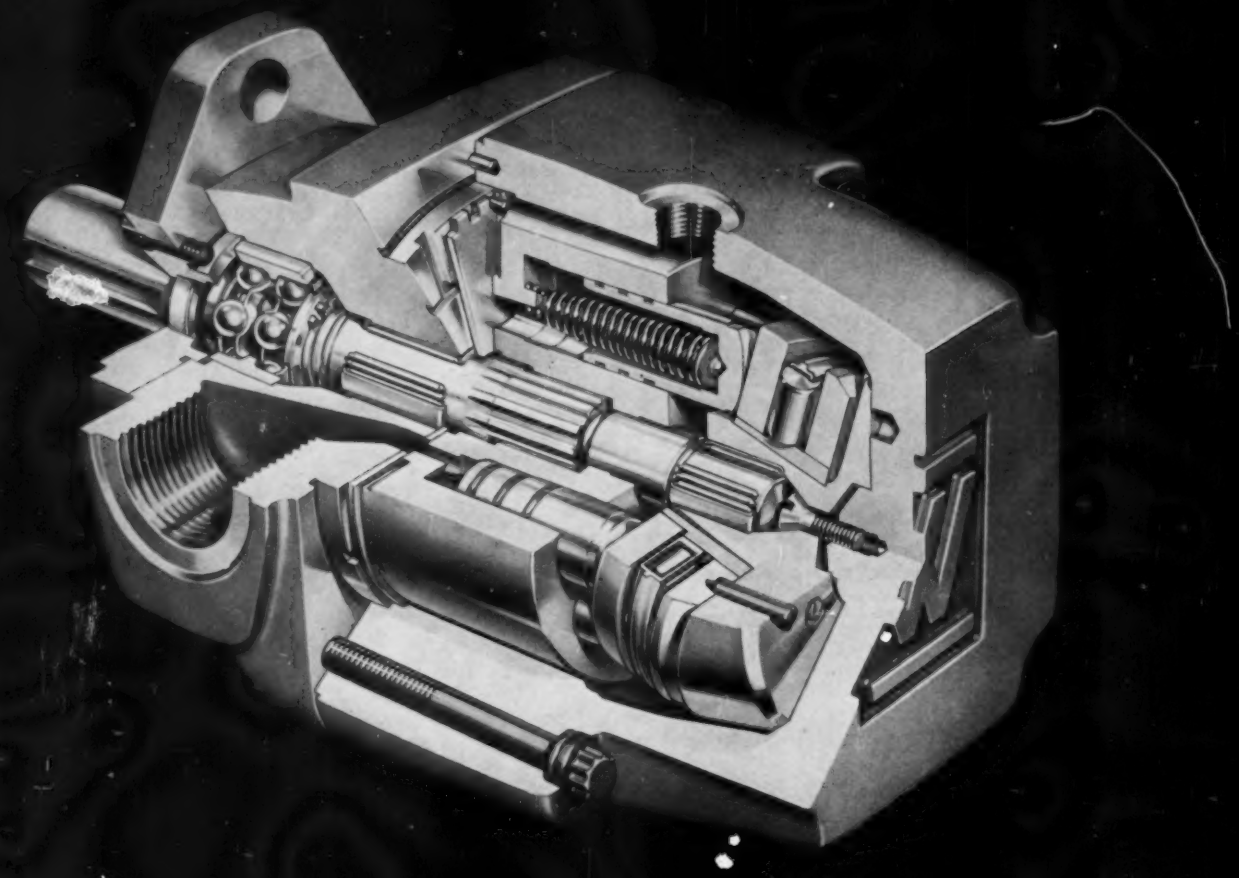
TURNING MACHINE is a self-contained hydraulic device with built-in motor-pump. Two hydraulic actuators are used, one for lifting, and one for positioning. The machine has electrohydraulic controls. It can lift 500 lbs. of sheet metal using vacuum suction cups. Built by Pathex Ltd., Toronto, this unit is part of their 8,000-ton capacity hydraulic laminating press system.



HYDRAULIC PRESS designed and built by Erie Foundry Co. for the California Division of Lockheed, Burbank, forms super strength plastic parts. The 1000-ton press has an 8-foot stroke. 1000 F temperature, in electrically heated platens molds epoxy, silicon, phenolic and cermet (ceramic and metal) materials.



HYDRAULIC PUMP USES PLANT AIR for small volume demands at medium or high pressures. Built by Aldrich Pump Co., Allentown, Pa., this unit can be operated without auxiliary equipment. It has an air filter, regulator, lubricator and hydraulic pressure gage. In the application shown, the pump is being used to test a length of transmission pipe at 300 psi.



WEBSTER'S NEW C3F PISTON MOTOR AND PUMP

compact, simple design ■ exceptionally serviceable!

This new hydraulic power unit — developed especially for the machine tool field — features unique application and servicing advantages. Examples: (1) small "package" to fit in close quarters — SAE "A" size mounting can be used with easy access to both mounting holes; (2) simplest axial-type piston pump on the market — fewest parts, fewer potential trouble spots, greater economy; (3) easily serviced — all critical moving parts can be readily replaced in the field. Shaft can be exchanged by disassembling seal end only; (4) unit can be disassembled and the rotation reversed in the field — can be arranged for use as a dual rotation motor; (5) variety of mounting styles — mounting plate and seal assembly is a separate piece and can be furnished in several mounting styles; (6) drive shafts are available with keyways or splines.

The C3F Series can be used as a hydraulic motor (remote rotary locations, screw feeds — anywhere an electric motor might be used) or as a hydraulic pump. . wherever high torque and smooth, steady force are required. It is available in four sizes — from .72 to 1.81 cubic inches per revolution. Capacities range from 3.3 to 8.5 gpm at 1200 rpm; 7 to 18 gpm at 2400 rpm.

C3F SERIES

FIXED DISPLACEMENT
AXIAL-TYPE PISTON
MOTORS AND PUMPS

Drive: direct, gear or belt

Displacements: four sizes; .72, 1.09, 1.45, 1.81 cu. in. per rev.

Porting: Side ports — horizontal or vertical — handle 1" NPT inlet or 1¼" "O" ring straight thread

Capacity: 3.3 to 8.5 gpm at 1200 rpm
7 to 18 gpm at 2400 rpm

Speeds: to 3000 rpm

Pressures: continuous duty 3000 psi, intermittent rating to 3500

When used as motor:

Torque range (theoretical): four sizes; 11.52, 17.28, 23.04, 28.80 inch pounds per 100 psi

Output: 5.5 to 14 hp. at 3000 psi at 1200 rpm
11 to 28 hp. at 3000 psi at 2400 rpm

OIL HYDRAULICS DIVISION
WEBSTER ELECTRIC
RACINE · WIS

franklin adv. H127A

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FLUID POWER AT WORK

Book Review

Etudes et Determinations des Systemes Hydrauliques, by M. Guillon, 443 pp, published by Dunod, Paris, France.

This recent hydraulic text, written in French, is divided into three parts: statics, dynamics, and applications.

The section on statics treats laminar and turbulent flow and various pressure losses. Equations are given to calculate these losses. Other chapters deal with transmission and dissipation of hydraulic energy, hydrodynamic pumps, directional control valves, relief valves, hydraulic balance, and servo-mechanisms.

Other subjects discussed in detail are electrohydraulic analogies, servo response, input-output relationships, and system stability.

MOLDED SEALS

Complete Stocks

Dependable Engineering Service

LINEAR SEALS
"O" Rings
"V" Rings
"U" Cups
Piston Cups
Valve Packings
Diaphragms
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Gaskets
Wiper Rings

ELASTOMERS
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NFPA News

Group Approaches New Projects

PHILADELPHIA—Standards and specifications dominated technical sessions of the National Fluid Power Association at its annual Fall meeting. Representatives of hydraulic and pneumatic component manufacturers considered new areas to expand their efforts.

• **Servomechanisms**—Fluid power is in a competitive race with electrical systems in the growing field of industrial servomechanisms. This was evident in a workshop session in which representatives of three servo manufacturers were present as guests of the Association. Harvard B. Kolm, Moog Servocontrols, Inc., J. W. Broome, Servocontrols Div., Oilgear Co., and Theodore C. Smith, Pegasus Laboratories, Inc. outlined needs for standards covering terminology, symbols, mountings and performance. The need for education in designing servo systems was also emphasized. Most suppliers of servo components must now take *system* responsibility because users are not capable of engineering a complete system.

Wesley Master, Dynex Co. pointed out that availability of servo components and information

Continued on page 40

The National Fluid Power Association represents 72 manufacturers of cylinders, valves, pumps, and other hydraulic and pneumatic components. Its activities are in management, marketing, education, and technical projects. Recent publications include: *Glossary of Fluid Power Terms* and *Recommended Dimension Identification Code for Fluid Power Cylinders*. Association headquarters are at 5595 N. Hollywood Ave., Milwaukee 17, Wisconsin.

Honey, the boss is really *tickled* with your idea about installing Houdaille's HydRoAc

He should be tickled. HydRoAc can't be beat for efficient (up to 95% or over) conversion of hydraulic power into rotary motion. And all this with very low internal leakage. The most complete line of hydraulic rotary actuators comes in four different sizes from the 16 lb. "Tiny" to the 350 lb. "Large". There are 20 variations available for each of the four sizes...80 separate rotary actuators from which to choose! Foot mounted or end mounted, they operate on air or other media and at temperatures from -40° to 275°F. Each one has snubbing over the last 5° of travel. Torque range is from 1500 to 228,000 lbs. Tickle your boss ...send for your Houdaille HydRoAc catalog right now.

.. Specialists in rotary type hydraulic equipment

Houdaille Industries, Inc.

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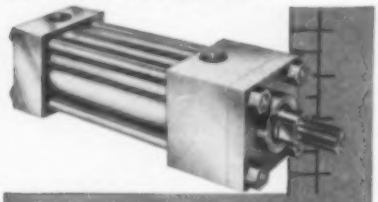
NEW O-M SQUARE-HEAD AIR AND HYDRAULIC CYLINDERS

GIVE THE PERFORMANCE YOU EXPECT... AND MORE



Air—(rated 200 psi)
Hydraulic—(rated up to 2000 psi)
Meet JIC Standards 1 ½" to 14" Bores

- Long Service
- Uniform Performance
- Dimensional Interchangeability
- High Operational Efficiency
- Compact — Saves Space
- Quick, Easy Maintenance

Made of the highest quality materials and seals, these new components combine modern design, the latest and best engineering advancements with O-M specialized "know how" and precision workmanship.

New Series "K" Air Cylinders

Construction features include brass cylinder barrel, chrome-plated, high tensile steel piston rod with a minimum yield strength of 90,000 to 100,000 psi. Rolled and machined steel heads and extra long cartridge-type rod bearing assure perfect alignment of piston rod.

New Series "L" Hydraulic Cylinders

Similar in many construction features to Series "K", but specifically designed for hydraulic service. Incorporate vee-type rod packing and a cylinder barrel of micro-honed steel tubing which are best suited for hydraulic operations.

With the addition of the new Series "K" and "L" to the Ortman-Miller major line of air and hydraulic cylinders, you can now rely on O-M for *all* of your low and medium pressure cylinder requirements.

Mail coupon today for complete details. All cylinders in Bulletins 115A and 116 have been dimensioned in accordance with NFPA recommendations for your convenience.

ORTMAN-MILLER MACHINE COMPANY
1143rd Street, Hammond, Indiana

☐ Have representative call
Please send Bulletin(s)

☐ 115A—Series "K" ☐ 116—Series "L"

NAME_____

POSITION_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

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FLUID POWER AT WORK

about them is hindering use of hydraulic systems in contrast to electrical systems. Even though hydraulics may have inherent advantages of size, power, and control, standardization and availability could favor electrical systems. Component information which the servo engineer needs must readily be available to realize the full potential of hydraulic servomechanisms.

• **Accumulators**—An important NFPA project now nearing completion is a standard of accumulator design and construction. At present, state industrial codes and insurance companies force accumulator manufacturers to comply with the ASME code for unfired pressure vessels, because there are no regulations applying specifically to hydraulic accumulators. This often results in overdesign for hydraulic applications. An NFPA committee including Herb Schmiel, Parker-Hannifin Corp., Charles Cartledge, American Bosch Div., and Andrew Zajdler, Superior Hydraulics Div. are adapting the ASME Code, for use

Continued on page 42

BRIEF NOTES

MACHINE TOOL ORDERS RISE . . . September 1961 net new orders for metal cutting machine tools totalled $56,750,000 the highest monthly figure since March 1957, and 23.5% above the monthly average for 1961. New orders for metal forming tools were $10,550,000, slightly above the previous month, and 0.8% below the monthly average of 1961.

R. D. WOOD CONSOLIDATES . . . R. D. Wood Co., has transferred its general offices from Philadelphia to Florence, N. J. in a move to consolidate all company activities in one location. The firm manufactures large industrial hydraulic presses.

TO MARKET BERRY-DOWTY PUMPS . . . Sales and service of Berry-Dowty hydraulic gear pumps and motors will be handled by the Bellows-Valvair Div. of International Basic Economy Corp., New York. Bellows-Valvair will market Berry-Dowty pumps in the United States and Puerto Rico for original equipment manufacturers and for in-plant use in the general industrial field.

CONVERTS MACHINE TOOLS TO TRACER OPERATION . . . The Detroit Broach & Machine Co., Rochester, Mich. has released a 2-page technical leaflet which tells how a standard lathe can be converted into a highly versatile, hydraulic tracer controlled machine.

PARKER-HANNIFIN ORGANIZES INDUSTRIAL MARKETING GROUP . . . The Parker-Hannifin Corporation, Cleveland, has established the Parker-Hannifin Industrial Group to combine the product and marketing activities of related company divisions serving the fluid power field. The new group will be headed by R. W. Cornell, executive vice president of the corporation and will include the Fittings and Hose Div., the Hydraulic Valve Div., and the Hannifin Co. Div. Otto J. Maha has been named Vice President of the new Industrial Group. Don A. Cameron is vice-president-sales, and Carl J. Giblin moves to Chicago to head the Industrial Group's Power Cylinder Div. Joseph D. Shaffer takes over Giblin's position as manager of the Parker Hydraulic Valve Div. in Cleveland.

TO CONDUCT PACKING CLINIC . . . Garlock Inc., is planning an educational packing clinic to help engineers, purchasing, and maintenance personnel understand and solve packing problems. Slides are used to illustrate correct packing procedures. Pocket size maintenance fact books will also be available.

PALL CORP ACQUIRES MONTREAL FIRM . . . The Pall Corp., Glen Cove, N. Y. has announced the acquisition of Vector Laboratories, Inc., Montreal. Vector specializes in electro-mechanical and electronic controls.

Check these reasons why Ohio Drawn-Welded is your best buy

✓ OHIO is your most complete source for drawn-welded tubing—from ⅜" to 7¼" OD, from .028 to .344 wall thickness.

✓ OHIO has the most modern welded tube mills in operation today, backed up with 25 years of experience in the production of quality welded steel tubing.

✓ OHIO DRAWN-WELDED is a guaranteed product of Ohio Seamless Tube, SHELBY, OHIO, U. S. A., capital of steel tube production since 1890.

✓ At OHIO, welded and seamless tube production is *integrated*. The same practices, craftsmanship and facilities are employed to complete the processing of drawn-welded as we use on our seamless product, which is world-famous for its reliability.

✓ Check OHIO DRAWN-WELDED on your next tubing order for economy, dimensional accuracy, super finish, strength. You'll see why it's the best buy. A-3167A

Representatives in principal cities. Check: THOMAS', MacRAE'S, CONOVER-MAST, FRASER'S, SWEET'S FILE.

OHIO SEAMLESS TUBE
Division of Copperweld Steel Company
SHELBY • OHIO
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

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TRANSFER MACHINE BUILT BY BUHR MACHINE TOOL CO., ANN ARBOR, MICHIGAN

Automated GIANTS like this

REQUIRE STRONG HYDRAULIC *HEARTS* EVERY MINUTE OF THEIR WORKING LIFE

24 RACINE PUMPS *operate this 58 station 500-ton transfer machine*

The precisioned flow control of RACINE PUMPS assures the split-second timing and efficiency required to operate this complex Buhr Transfer Machine . . . custom-built for the completely automatic machining of 120 auto-cylinder heads hourly for a leading automotive manufacturer. Compact RACINE VALVES control feeds and reverse movements on all 323 operations performed by the machine. RACINE 4-WAY SOLENOIDS help one man operate this mechanical giant. Buhr has used RACINE PUMPS and Reservoir Units on custom-built machines for the automotive industry for over 10 years.

RACINE

Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

Circle **96** on Reader Service Card

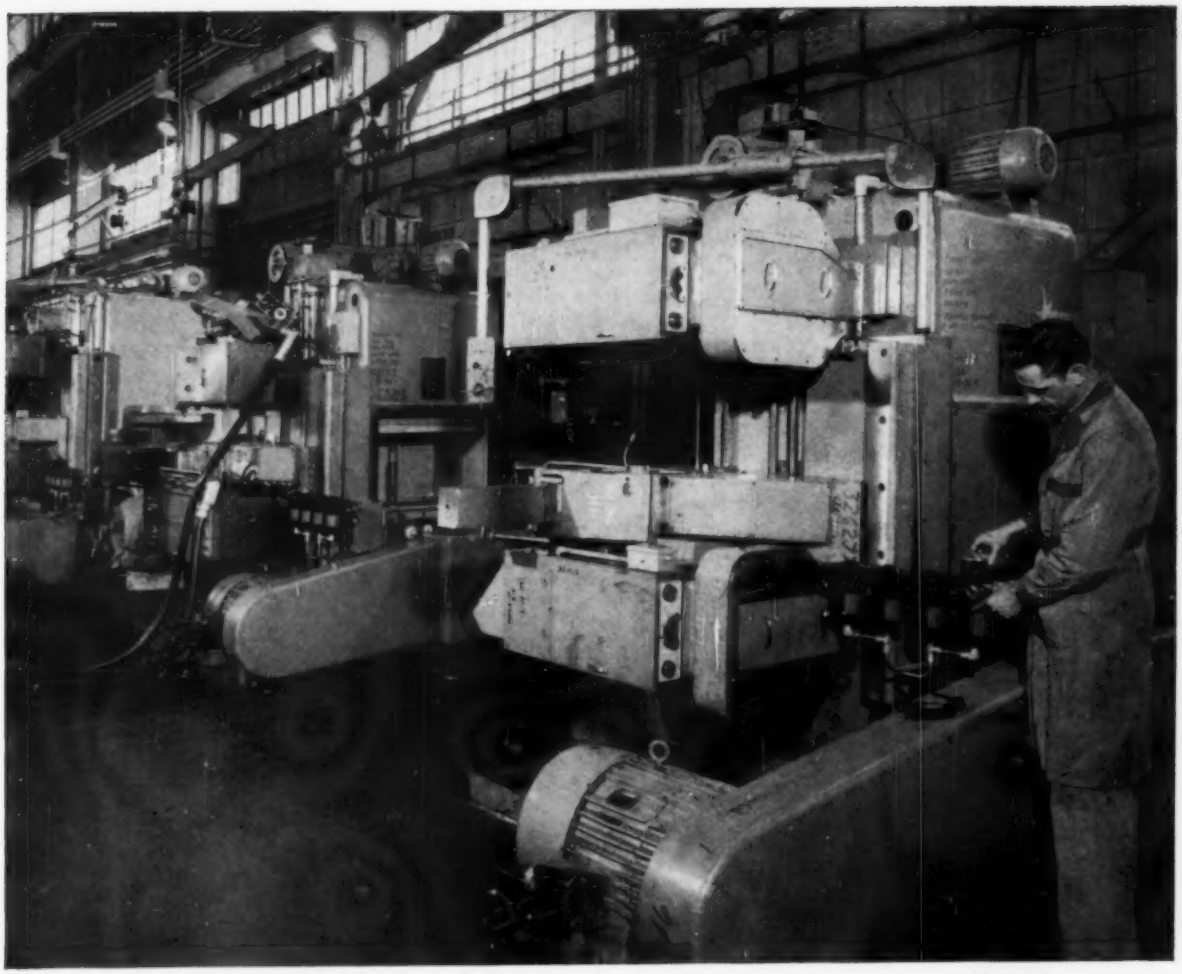
FLUID POWER AT WORK

with accumulators. The next step will be to have this approved as the governing specification.

• **Valves**—A uniform, meaningful way of describing valve performance is needed. In a workshop session headed by George Goepfrich, Skinner Electric Valve Div., valve pressure drop specifications were under discussion. These are more effective for circuit design purposes than port size which is so often the guiding factor in selecting a valve. A common testing procedure is needed for determining valve pressure drop. The schedule for NFPA activities in valves covers coding and classification (which is almost completed), capacity rating, and marking. Committees working on these projects will be composed of both hydraulic and pneumatic valve manufacturers.

• **Filters**—There is a need for educational efforts in good filtration techniques to make fluid power better understood and more useful. Borje Rosaen, of Rosaen Filter Co. emphasized the primary need for information on good filtering techniques: where filters should be installed and what kind should be used. Another project of a new committee will be to delop filter ratings. Reed Schroeder of Schroeder Bros. Corp. will direct these activities together with Rosaen.

• **Symbols**—International graphical symbols developed by the European Oil Hydraulic Technical Commission were reviewed at the NFPA meeting. Copies of the proposed symbols have been sent to all member companies for comments before they are submitted to the International Standards Organization for adoption as an international standard. Although the symbols are styled after present JIC Standards, they eliminate letters and words, so they are equally useful in all countries. This NFPA project is a step in promoting trade in fluid power equipment with the European Common Market countries. ▼▼▼



New 10-micron filtration for both hydraulic and lubricating systems of re-designed Bullard dynatrol vertical turret lathe. Made of resin-impregnated, waterproof paper, Purolator Micronic filters withstand a differential pressure of 75 psi . . . temperatures up to 275°F.

PUROLATOR MICRONIC® FILTERS IMPROVE FILTER EFFICIENCY 270% ON NEW BULLARD COMPANY TURRET LATHE AND BORING MILL

Ten micron filtration assures maximum operating efficiency and long equipment life. "Tolerances are a lot closer on our new vertical turret lathe and horizontal boring mill," says Bill Glynn, Project Engineer for Bullard. "Parts like the new hydro mesh feed brackets and solenoid valves would wear out fast if we used the old steel filters which only filter down to 37 microns."

Used for both hydraulic and lubricating systems. "We upped filtration efficiency some 270% by installing Purolator Micronic filters on both hydraulic and lubricating systems.

"With this new 10-micron full-flow filtration we should get the best possible performance from our new equipment."

Element replaced only every 1000 hours. "Replacing the Micronic filter element takes only a minute," Glynn goes on to say. "And since a new one is needed only every 125 8-hour working days or so, we feel these new filters will cut downtime and production costs, too."

Ideal for precisely-finished new equipment. Reliable, full-flow filtration down to 10 microns means that Purolator Micronic filters give maximum protection to precisely-finished new equipment. These same filters can also mean improved performance and longer service life from existing equipment.

For full information, contact your nearest Purolator Sales Office, or write: Purolator Products, Inc., Rahway, N. J.

Filtration For Every Known Fluid

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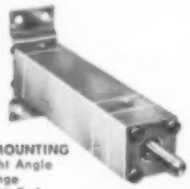
PRODUCTS, INC.
RAHWAY, NEW JERSEY AND TORONTO, CANADA

A MOUNTING
Parallel Base

NOPAK®
CLASS 7 CYLINDERS
7 Universal Mountings
ONE BASIC BODY

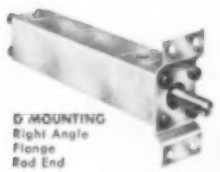
BB MOUNTING
Barrel Bolted

This is the only truly modular cylinder that is mass produced, yet gives you all the installation advantages of a custom-built unit. Any stroke length from 1" to 20" is immediately available in bores from ¾" to 3." Pressure rated for 200 p.s.i., air; 1000 p.s.i., oil, in the most popular stroke lengths.


C MOUNTING
Right Angle
Flange
Blank End

Roll 'em Over!

UNIQUE SQUARE BARREL†: Made of seamless extruded, aluminum alloy, drawn to a 16 micro inch finish, hard anodized to assure an extremely durable surface. Life tests reveal no wear in bore after millions of cycles. The four-square flush barrel provides unique and exclusive opportunity for direct bolt-in mounting into any of its sides or longitudinally from either end. (See Mounting HB & BB.)


D MOUNTING
Right Angle
Flange
Rod End

Blitz Bolt 'em!

NO TIE RODS! NO LOCK RINGS! All components including Mounting Attachments neatly contained by only four (4) bolts at each end.

E MOUNTING
Pivot Tongue

Shine 'em up!

STREAMLINED FLUSH FOUR SQUARE DESIGN — No tie rods; no humps; no bumps, no dirt catching, inaccessible, hard to clean contours.

F MOUNTING
Trunnion

Hang one on!

MOUNTINGS UNLIMITED: — The 5 Universal Mounting Attachments are quickly bolted to the basic body. In addition, the four-square design allows rotating and inter-mixing these attachments. Now add to this the exclusive Direct Head Bolt and Barrel Bolt Mountings and NOPAK Class 7 becomes the most universal air and hydraulic cylinder ever developed. A natural for even the most difficult applications.

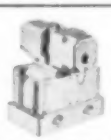
HB MOUNTING
Head Bolted

Spin 'em Around!

CYLINDER HEADS: — as well as head plate, are precision cast and machined aluminum alloy. The four-square heads can be readily rotated to position ports for most convenient piping. No matter how rotated, the heads align perfectly with the square barrel, resulting in clean, flush surfaces. Heads also provide opportunity for direct bolt-in mounting. (See Mounting HB.)

Other NOPAK "CVA*" Products

NOPAK "V" 4-Way, Pilot Operated Slide Valves Small, compact, 3- and 4-way valves for direct or remote control. Either single or double air pilot or solenoid actuated. Simple, proven design, durable construction insure trouble-free operation.



NOPAK - MATIC Poppet Type, Pilot Operated Valves Fast acting, high volume air valves from ¼" to 1¼" with master (air piloted) single or double solenoid. Side or bottom ported sub-plates or manifolds. Removing cover plates affords easy access to piston poppets housed within removable, interchangeable cartridges. 100% J.I.C.

†Patent Pending

*Cylinders, Valves, Accessories. NOPAK offers a complete line of matched Fluid Power components.

NOPAK
VALVES & CYLINDERS

NOPAK DIVISION
Galland-Henning Mfg. Co.
2743 S. 31st St., Milwaukee 46, Wis.

Circle 46 on Reader Service Card

FUTURE EVENTS

SAE AUTOMOTIVE ENGINEERING CONGRESS & EXPOSITION
January 8-12
Cobo Hall
Detroit

NATIONAL PLANT ENGINEERING & MAINTENANCE SHOW
January 22-25
Convention Hall
Philadelphia

ASME-SAM MANAGEMENT ENGINEERING CONFERENCE
April 5-6
Statler Hilton Hotel
New York

NFPA SPRING MEETING
April 8-11
Edgewater Gulf Hotel
Edgewater Park, Miss.

ASME PRODUCTION ENGINEERING CONFERENCE
April 24-26
Van Curler Hotel
Schenectady

ASME DESIGN ENGINEERING CONFERENCE & CONCURRENT SHOW
April 30-May 3
Chicago Exposition Center

SAE A-6 COMMITTEE MEETING
Aerospace Fluid Power Systems & Equipment
April 30-May 4
Sheraton-Mt. Royal Hotel
Montreal

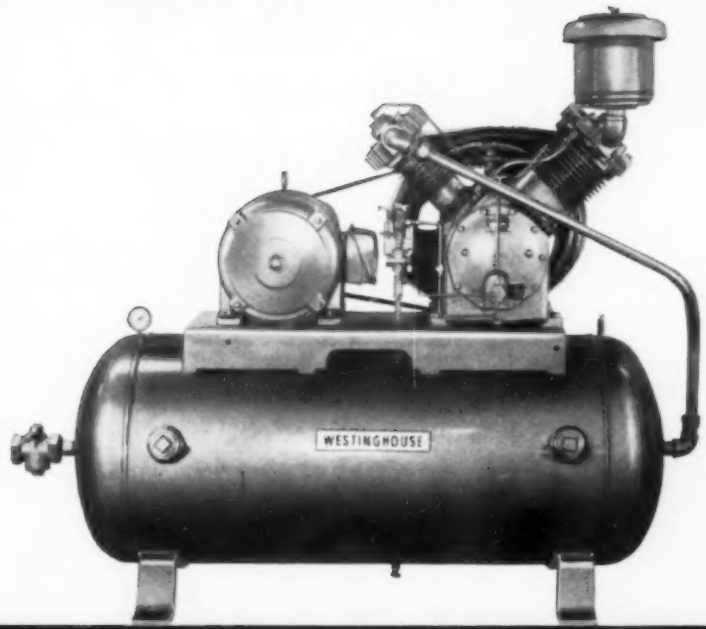
ASTME ENGINEERING CONFERENCE & TOOL EXPOSITION
May 7-11
Public Auditorium
Cleveland

ASME SUMMER ANNUAL MEETING
June 10-15
Hotel Frontenac
Quebec

ASME AVIATION CONFERENCE
June 26-28
University of Maryland
College Park

Circle 71 →

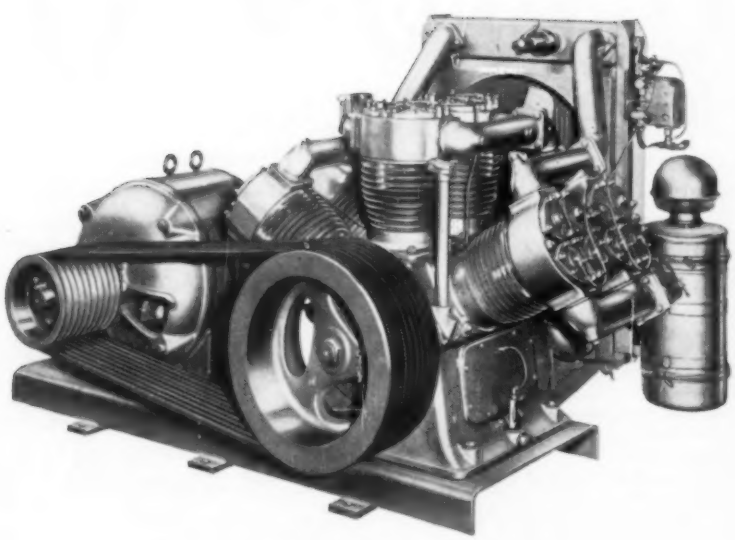
Make LE ROI your one-stop source for AIR COMPRESSORS



WESTINGHOUSE unit type ½ to 15 hp. 17 models: 2 to 71.7 cfm—80 to 250 psi

WESTINGHOUSE single- and two-stage compressors are ideal for jobs in the unit type class with moderate air demand. You get long-lived dependability at low first cost. Upkeep is negligible. Units incorporate thermal overload protection, positive starting unloader, air cooled deep-finned cylinders, and corrosion-resistant automatic spring loaded floating valves.

Crankshaft is ball-bearing mounted for stability, and matched V-belt set assures balanced drive line wear. Compressors are available with horizontal or vertical tank, or bed-plate mounting. Load-unload or start-stop control is standard. Options include dual control, water-cooled aftercooler, and automatic drain valve for receiver.



LE ROI stationary type 25 to 100 hp. 4 models: 92 to 450 cfm at 125 or 175 psi

LE ROI stationary compressors provide economical and flexible air power for your heavy industrial jobs. Made in 25, 50, 75, and 100 hp sizes, these two-stage units can be used as central air supply — or you can spot units at various points of use, thus minimizing pipe runs and air loss. Air-cooling permits indoor and outdoor use, and compactness conserves space.

Features like forced-feed lubrication, large intercooler, high-speed fan, and balanced design extend motor and compressor life and cut upkeep. You can pick standard models with either dual control or continuous running load-unload control. Option extras include: crankcase oil filter, oil pressure safety switch, intake silencers, belt and intercooler guards, and water-cooled intercooler.

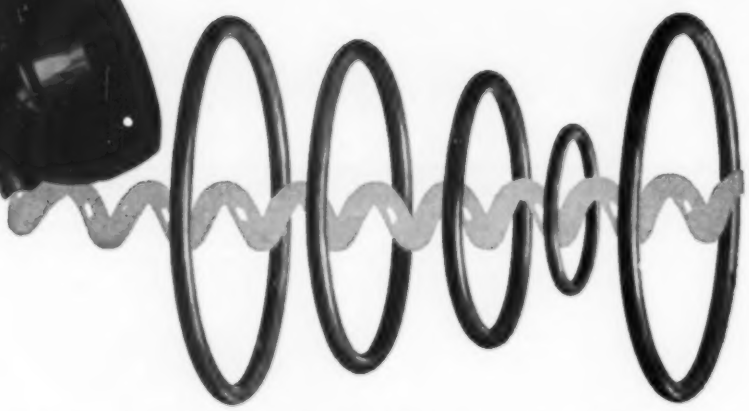
Ask your Le Roi Distributor for additional information. Or send for Bulletin SG-3 covering the entire line. Write to Le Roi Division, Westinghouse Air Brake Co., Sidney, Ohio.

SC-102

LE ROI Division of Westinghouse Air Brake Co. Sidney, Ohio

Call your National Applications Engineer for

engineering help
fast delivery
uniform quality
special compounds
on O-Rings



National's District Field Offices give you fast service on O-Ring engineering problems and O-Ring procurement. You talk with seasoned field engineers equipped with the latest O-Ring information and backed up by the plants of one of America's largest sealing products manufacturers. National O-Rings are precision-made, uniform in quality, specified and used by leading equipment manufacturers across America.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
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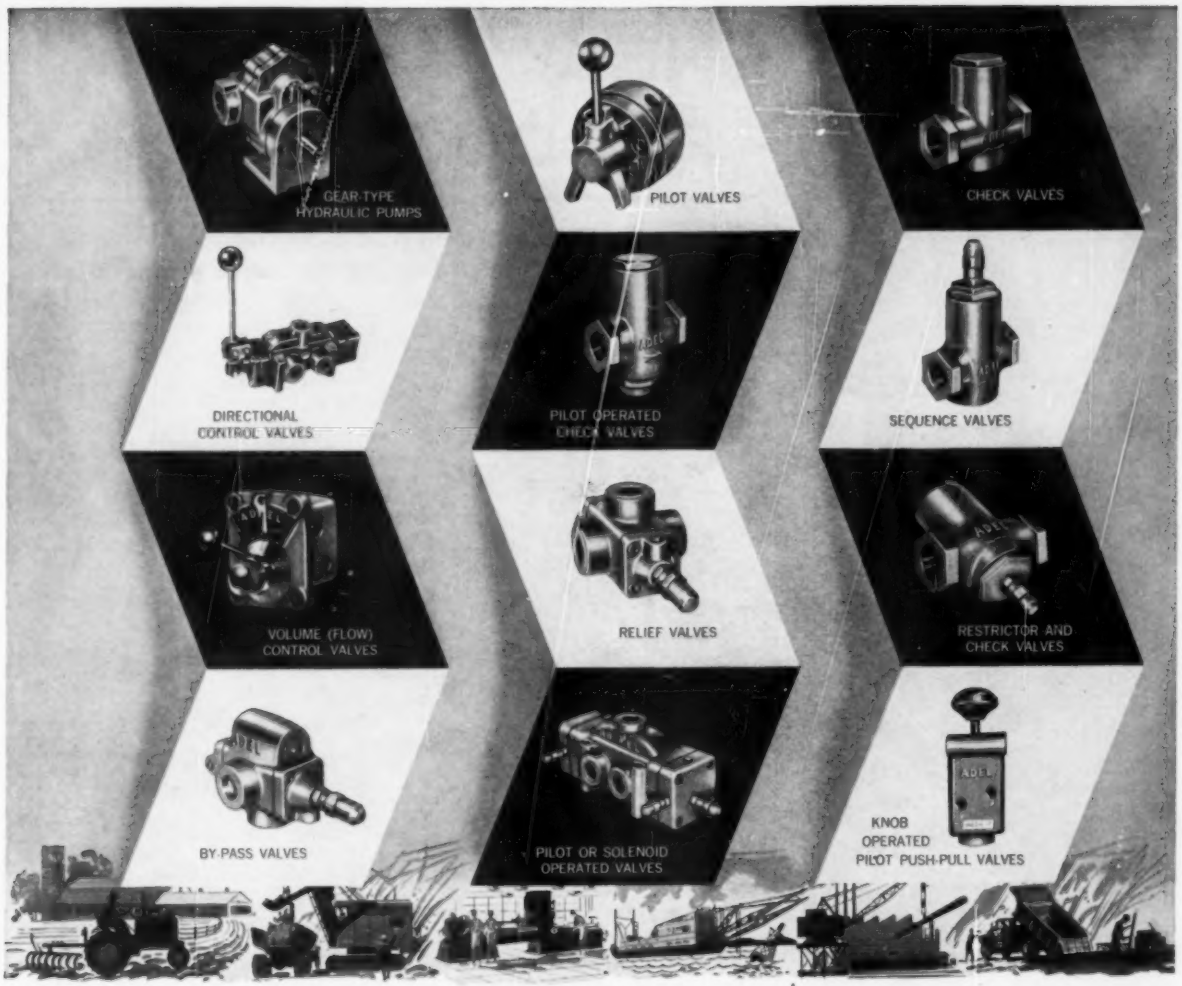

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....synonymous for fail-safe performance!

A complete line of valves and pumps for every application ADEL contributes cost-savings to the Original Equipment Manufacturers, not only in terms of initial cost, but in design features that provide preventive maintenance and, most important, *maximum operating efficiency over the years.* ■ If you need a hydraulic valve or pump replacement for your equipment... *specify* ADEL and you won't need another! ■ **You name the application...** ADEL has the Precision Hydraulic Equipment to meet your requirements. ■ ***Write for complete engineering specifications.***

Designers & Manufacturers of Industrial & Marine Hydraulic Control Equipment

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IMAGINATION FOR SALE!

CIRCLE OF POWER

Supplying hydraulic, electrical and air power from a stationary base to a rotating superstructure was solved by this UH-designed swivel. This "circle of power" carries two high pressure hydraulic lines, tank line, air line, and seven electrical lines, thus permitting 360° continuous rotation of the superstructure while eliminating one engine. Engineered solutions of hydraulic problems is a UH specialty . . . but whether your problem is complex or commonplace, call or write us today.

UNIVERSAL HYDRAULICS

DIVISION OF HOLAN CORPORATION
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WILLOUGHBY, OHIO
PHONE: 946-2100

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NEW PRODUCTS

Circle the numbers on the Reader Service post card for more information

AIR FILTER

Vented-type, breather cap with air filter filters particles as small as 40 microns. For use in hydraulic

reservoirs. Cap twist-locks securely on a close neck flange. Cap is secured by a chain fastened to the flange. Cap, flange, and chain are cadmium plated for protection against rust and corrosion.

Specifications: Strainer 30 Mesh Wire Screen; 3" deep, 1-15/16" in diameter.—*The Lenz Co., Dayton, Ohio.*

Circle **300** on Reader Service Card

TEST MACHINE

Designed for efficient testing and economic maintenance. Gauges, flow meters and other instrumentation are equipped for contamination-free re-calibration, without removal from the machine. All oper-

ating valves are cartridge units, screwed into manifolds. They can be removed without opening any lines.

Specifications: Ten basic models, in 5 console sizes. Rated for 5000-psi maximum, 3000-psi normal operating pressures. Flows of 5 to 60 gpm. Horsepower ratings 10 to 100 and higher. Available either 50 or 60 cycles. Usable with many fluids including MIL-H-5606, Skydrol, and Oronite. Gauge dials 6", to 1% accuracy, full scale. Flow meters to 2% accuracy, full scale. Aluminum alloy block manifolds with O-ring seals.

Designation: HA-100 Series.—*Greer Hydraulics, Inc., Los Angeles.*

Circle **301** on Reader Service Card

BEARINGS

Two-piece, ultra-precision miniature, self-aligning, spherical, plain bearings and rod end bearings have been developed for maximum performance and long life in compact, light-weight assemblies.

Specifications: Bore sizes from .046" to .156" with ultimate static

load ratings from 225 lbs. to 2550 lbs. Only in corrosion resisting steels.

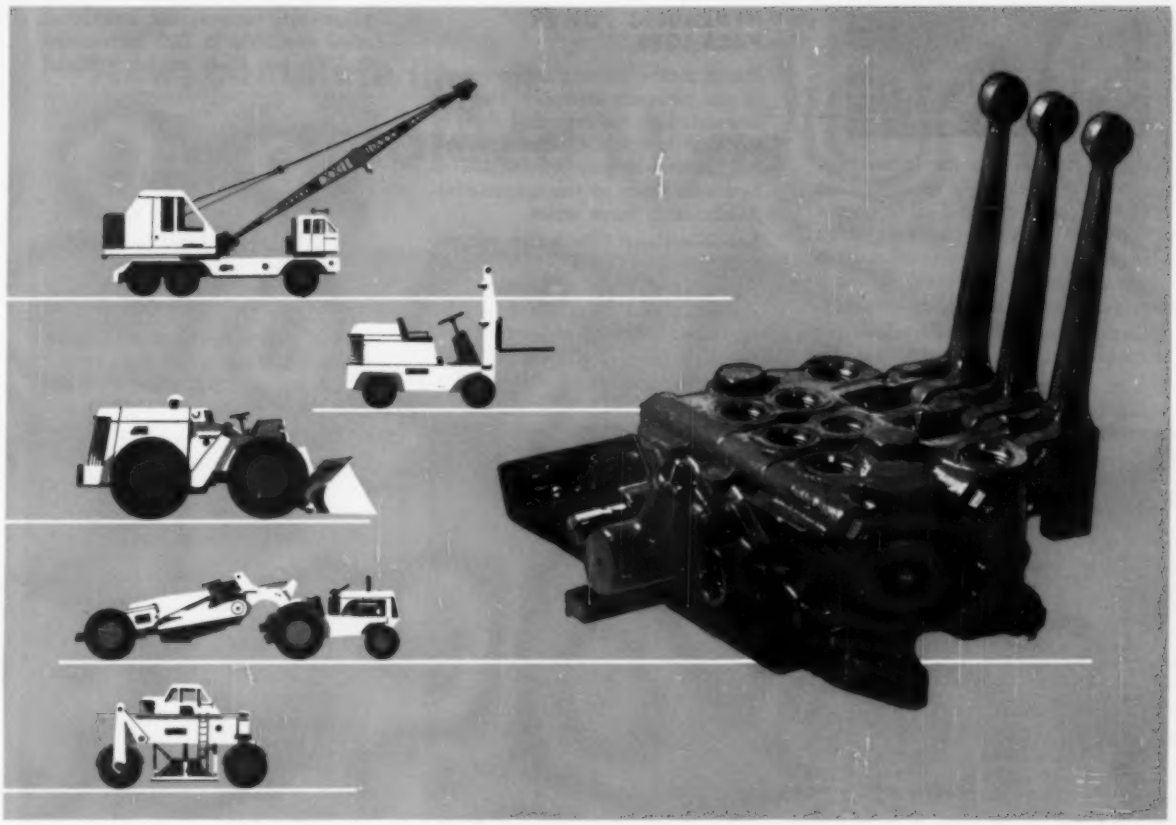
Designation: BMP miniature series. —*Southwest Products Co., Monrovia, California.*

Circle **302** on Reader Service Card

ELECTRONIC BEND ANGLE SELECTOR

Programming of up to fifteen different angles (counting correction factors and springback) is done with this selector on bending presses and machines. Selector matches electrical impulses from signal potentiometers. Each angle dial is equipped with a 3-digit micro-dial graduated to tenths of a

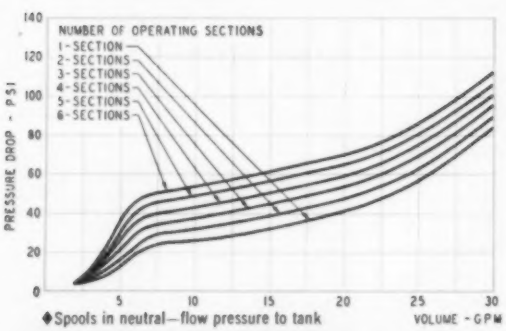
Continued on page 50



FOR BETTER, SMOOTHER LOAD CONTROL . . .

VICKERS DIRECTIONAL VALVES OUTPERFORM THE REST

Pressure Drop Curves♦



♦Spools in neutral—flow pressure to tank

Feather control of the load and the capacity to do more work over the entire 0 to 2500 psi operating range are yours with the new Vickers CM11 Series multiple unit valves. Not only will they handle the needs of today's most modern mobile equipment but they also have the built-in capacity to meet all foreseeable future needs.

For an indication of how these ultra-compact valves could improve performance of your equipment, check the pressure drop curves. Then, compare them with pressure drops on control valves you are now using. Reduced pressure drop means less horsepower wasted in the valve—more work capacity on every type of mobile equipment. This reduced pressure drop is the result of Vickers new, patented partial-flow by-pass feature.

Improved metering to eliminate jerkiness when raising or lowering loads . . . greater installation and service flexibility with Vickers-pioneered sectional design . . . choice of spool designs to meet wide range of operational needs . . . new enlarged porting . . . all are described in detail in Bulletin M-5112. Write today to Vickers Incorporated, Detroit 32, Michigan.

VICKERS®
DIVISION OF SPERRY RAND CORPORATION

1005

NEW PRODUCTS

degree to provide maximum precision in bend angle settings. One of two compensator dials applies a constant degree of overload to all preset angles. The second adds a percentage of overbend to each angle to insure workpiece accuracy.

Designation: Dial-A-Bend.—*Pines Engineering Co., Inc., Aurora, Ill.*

Circle **303** on Reader Service Card

HYDRAULIC POWER PACKAGES

Pump, motor, valving and reservoir in one compact assembly. Pump is connected to the extended shaft of the electric motor. Common mounting. Requires only connection of hydraulic lines to the actuator(s). Available in three series.

Specifications: First series: outputs to 8-gpm; either one or two solenoid (directional) valves. Overload relief adjustable to 1500 psi. Connections for external cooler. Second series: same output; up to three, manually operated valves. Non-adjustable, tamperproof overload relief available in 250 increments to 1500 psi. Basic models without

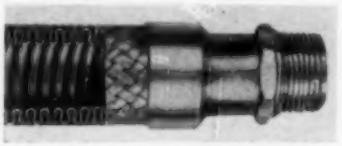
control valves; outputs to 5 gpm. Electric motors in five sizes from 1 to 5 hp at 1800 rpm; 220/440 volt three phase or 115/230 volt single phase.

Designation: Series PKS1, PKM1, PKM6.—*Vickers Inc., Div. Sperry Rand Corp., Detroit.*

Circle **304** on Reader Service Card

METAL HOSE

All-metal bronze and carbon steel flexible connector, designed for



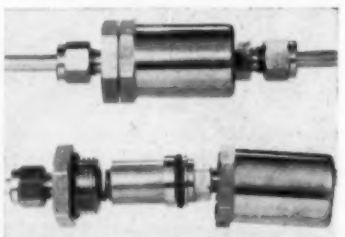
conveyance of gases and fluids to 750 F. Stainless steel versions suitable for temperatures to 850 F and 1400 F. Braided outer cover and corrugated inner tube for flexibility and extra strength. Eliminates hook-up misalignment, absorbs expansion movement, dampens troublesome vibration. Available from stock. Many couplings and flanges.

Designation: UC3.—*Universal Metal Hose Co., Chicago.*

Circle **305** on Reader Service Card

INLINE FILTER

Unusual design permits removal and replaement of the filter element



without removing the filter housing from the system. Large filtering area minimizes pressure drop and

Continued on page 52

BHEW

Hydraulic Cylinders

- Basic Designs
- Specific Adaptations
- Superior Quality
- Application Engineering

BHEW SINGLE-ACTING GENERAL-PURPOSE CYLINDERS (1500 PSI DISPLACEMENT — RAM — STYLE SERIES) are designed around standard components but custom-built to suit *your* application. They're available in a variety of mountings (pin eye is standard) with adjustable or non-adjustable rod ends, with or without rod ends.

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- Self-adjusting rod wipers
- Honed steel barrel, high-tensile, hard chrome-plated rod ends
- Packings available for extreme high and low temperatures and most non-inflammable fluids.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems —

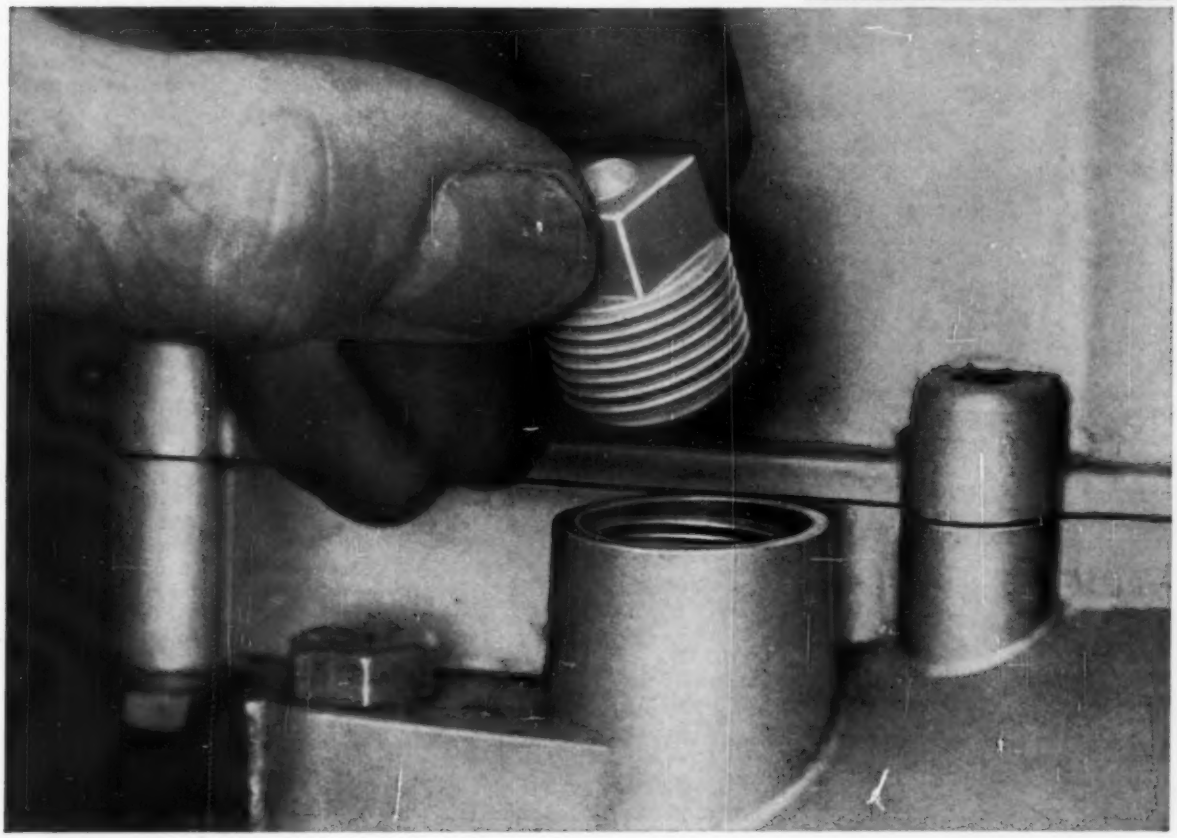
FREE!
Write today for Hydraulic Cylinder Engineering Reference Data — 78 dimensional basic designs for general — and special-purpose double-acting cylinders. SAVE TIME.

BENTON HARBOR ENGINEERING WORKS, INC.
622 Langley Avenue St. Joseph, Michigan

Circle **17** on Reader Service Card

New, complete line of

RB&W molded plugs



Avoid damage to threaded holes...get leakproof seal, too

You entirely eliminate the risk of damaging a costly tapped hole with RB&W molded plugs. If inadvertently crossed-threaded, their plastic material yields to metal threads—especially important where the tapped holes are in malleable metals.

They seal tightly under pressure, too. That's because all RB&W plastic plugs are molded hollow. Fluids under pressure exert radial forces that expand threads for an even tighter, dry, plastic-to-metal contact.

They resist corrosion, usually cost less than their metal counterparts, are available in various materials for various jobs.

DELRIN®—All-purpose RB&W Delrin® plugs ideally seal gases or fluids in compressors, pumps, valves, pneumatic and hydraulic systems, or any service involving contact with petroleum derivatives. Delrin plugs have metal-like mechanical properties, are suitable for use to 250°F.

NYLON—Made from *heat-stabilized* nylon (Zytel® 103), RB&W plugs withstand temperatures exceeding 300°F, remain leakproof at working pressures to 3000 psi.

NYLON—Made from *hydrolysis-resistant* nylon, (Zytel® 2281), RB&W plugs assure dependable service when continuously exposed to hot water or vapor.

POLYETHYLENE—RB&W polyethylene plugs, in two head styles, economically seal threaded openings to exclude dirt, contaminants, and moisture during shipping or handling. They can be tightened with fingers or wrench.

Send for data sheet which gives sizes and other specifications. Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

®Dupont trademark

R B & W

117th year

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle **62** on Reader Service Card

NEW PRODUCTS

increases element life.

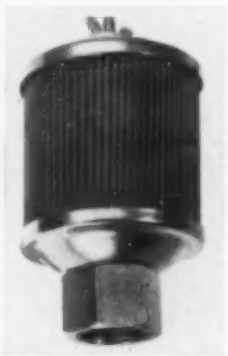
Specifications: Filters available in brass and type 316 Stainless Steel with Buna N or Viton A O-rings and rubber gaskets. Various micron size elements.

Designation: NUPRO Inline Removable Filter.—*Nuclear Products Co., Cleveland.*

Circle **306** on Reader Service Card

FLUID FILTERS

High-capacity intake strainer/filter for hydraulic equipment. Capacities of 5 to 10 gpm, 10 to 20 gpm, and 20 to 30 gpm. Larger capacities to be offered soon. Available in stand-



ard 100 mesh (140 micron) and 60, 80, 150, and 200 mesh for filtering particles from 260 to 75 microns. Mesh is monel; other parts of cadmium-plated steel.

Designation: Twin Life.—*Michigan Wire Cloth Co., Detroit.*

Circle **307** on Reader Service Card

STAINLESS STEEL AIR CYLINDERS

Stainless steel body, single acting (with spring return) or double acting. Anodized aluminum piston rod

guide, ground and polished type 304 stainless steel piston rod, and synthetic rubber U-cup seals. No tie rods.

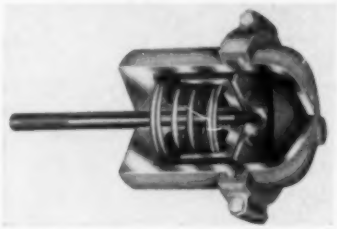
Specifications: Cylinders available with 3/4", 1-1/6",1-1/2" bores, to 24" stroke. Nose, pivot, or double-end mount.

Designation: Models 040-DP and DXP.—*Bimba Mfg. Co., Monee, Ill.*

Circle **308** on Reader Service Card

DIAPHRAGM ACTUATOR

No starting friction; responds immediately to the smallest variation in air pressure. Allows strokes up to



12", high operating pressures, and smaller diameter pistons than are normally used. Four types are available: air-to-close, spring-to-open (normally open); air-to-open, trapped air-to-close (normally closed); air-to-close with positioner normally open); and air-to-open with positioner (normally closed). Each available in a full range of sizes. Hydraulic fluid may be used to operate the air-to-close actuator.

Designation: RKL Rollomotor.—*RKL Controls, Inc., Hainesport, N. J.*

Circle **309** on Reader Service Card

HYDRAULIC RAMS

Heavy duty, double-acting, threaded or unthreaded hydraulic

rams have capacity range from 10 tons to 1000 tons. Unit illustrated is a 300-ton, 36" stroke, double-acting ram with hydraulically driven safety nut. Used for prestressing, lifting, or pushing applications; or for sustaining full loads for long periods. Infinite locking increments at any position; can be locked in either direction of ram travel under full load. Available with manual or remote safety lock nut.—*William S. Pine, Inc., Los Angeles.*

Circle **310** on Reader Service Card

For

wide capacity range...

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IMO®

power-hydraulic

pumps

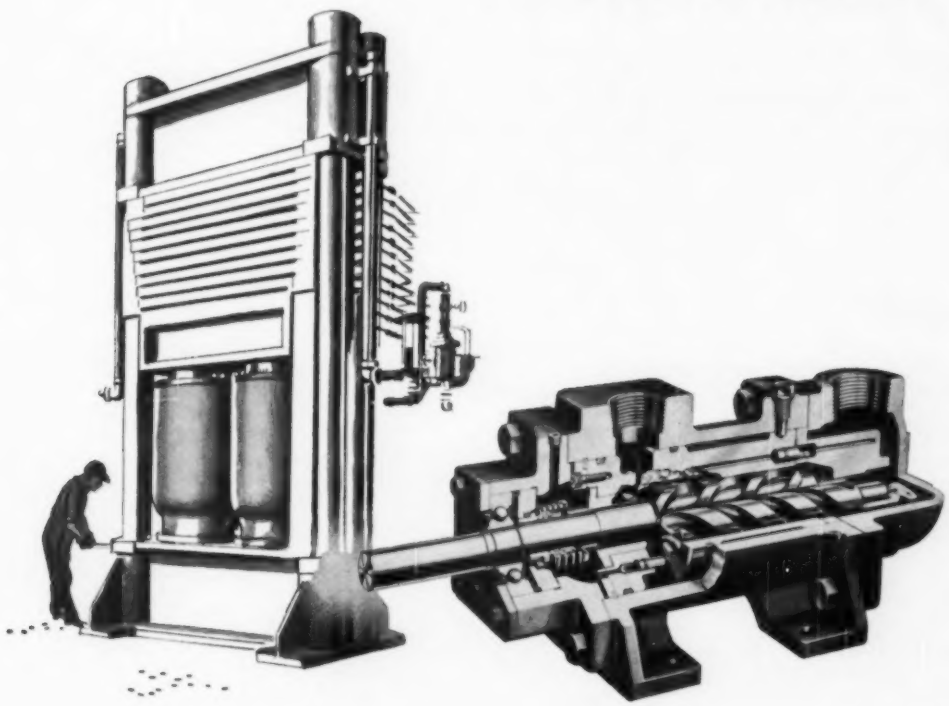
A single IMO pump can deliver up to
3000 gpm at 300 psi
1000 gpm at 500 psi
400 gpm at 3000 psi

The wide range of volume and pressure capabilities of IMO pumps finds extensive use in hydraulic-press applications. These, as a rule, require high capacities at low to medium pressures for pre-fill service, then low capacity at high pressure during the working part of the stroke.

Versatile IMO pumps deliver maximum performance in many varied power-hydraulic applications. Besides wide capacity range, IMO pumps offer non-pulsating flow, quiet operation, high speed and reliability . . . even with fire-resistant fluids. Compact design saves expensive floor space. Installed cost is lower than for other types of pumps. IMO pumps cut maintenance, too . . . only three moving parts!

For application and performance data, selection information, dimension drawings and tables, write for Bulletin IM-3200.

De Laval Steam Turbine Company, Trenton 2, New Jersey.



IM-DL-108

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Circle **35** on Reader Service Card

Specify Air Power!

STOCKED FOR IMMEDIATE SHIPMENT

Use variable-speed, explosion-proof

GAST AIR MOTORS

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

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PRODUCT BRIEFS

URETHANE SEALS . . . Withstand pressures of 3000 psi to 10,000 psi and higher with no backup rings. Efficient operation from −40 F to 225 F. High abrasion, tear, and wear resistance. Seal toughness permits finishes as coarse as 32 RMS. Available as U-cups, O-rings, cup packings, flange packings, rod wipers and washers.—*Disogrin Industries, Inc., Mt. Vernon, N. Y.*

Circle **311** on Reader Service Card

EXPLOSION PROOF AIR VALVES . . . High cycling speed (1000 cpm continuous duty) and valve endurance are prime features of solenoid valve. Short plunger stroke of 3/32" speeds operation, reduces coil heating. 150-psi air. ¼" to ⅜" pipe sizes; ¼" NPT conduit connections.—*Barksdale Valves, Los Angeles.*

Circle **312** on Reader Service Card

DIRECTIONAL CONTROL VALVE . . . Five-spool, open-center control valve for heavy duty mobile systems. Double-acting, or push or pull for single action. Each spool has its own load check valve. Integrated pilot-operated relief. Operating pressures to 2000 psi. Capacity to 12 gpm.—*Parker Hydraulics Div., Parker-Hannifin Corp., Cleveland.*

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DIAPHRAGM VALVE . . . Pneumatically-actuated valve with diaphragm of neoprene with nylon reinforcing, provides for "on-off" service and limited throttling control. Completely enclosed actuator spring assembly may be reversed to provide air-to-open or air-to-close service. Water, oil & gas service to 400 psig. ¼" to 3".—*Taylor Instrument Co., Rochester.*

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HYDRAULIC PRESSURE SWITCH . . . Capable of operating rates to 300 per minute. Oil-tight construction; strain relief prevents damage from shock on violent pressure surges. Pressure is adjustable from 2000 psi to 15,000 psi on rising pressure.—*Square D Co., Asheville, N. C.*

Circle **315** on Reader Service Card

SWIVEL FITTING . . . 360-degree rotation at one end; rotating end can extend 6". Operates from −65 F to 300 F, at pressures to 5000 psi. Force required to rotate or extend rod is less than 14 pounds in a hydraulic system at 3000 psi. Various fitting ends.—*Dumont Engineering Co., Long Beach, California.*

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4-VANE AIR PUMPS . . . Can provide vacuum to 26" Hg., pressure to 13 psig., and volumes from 12 to 54 cfm. Cast iron housing and rotor. Four sliding vanes maintain contact with housing by centrifugal force.—*Leiman Bros., Inc., Newark.*

Circle **318** on Reader Service Card

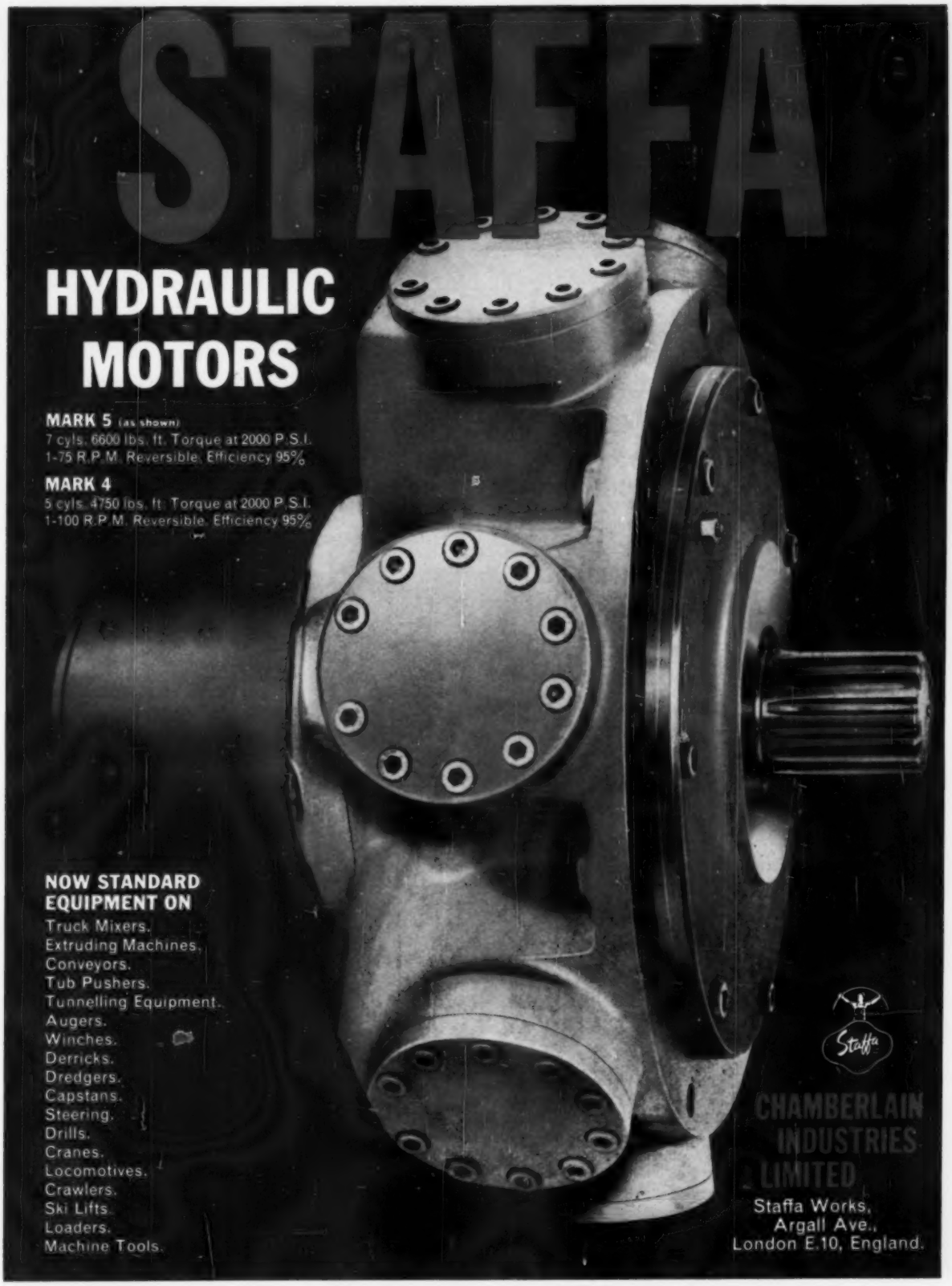
For more NEW PRODUCT reviews turn to page 116.

STAFFA

HYDRAULIC MOTORS

MARK 5 (as shown)
7 cyls. 6600 lbs. ft. Torque at 2000 P.S.I.
1-75 R.P.M. Reversible. Efficiency 95%

MARK 4
5 cyls. 4750 lbs. ft. Torque at 2000 P.S.I.
1-100 R.P.M. Reversible. Efficiency 95%



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These precision cylinders are backed by Gar Wood Industries' 50 years of experience in the design and manufacture of hydraulic equipment. Gar Wood is ready now to supply you with proven products manufactured under a government-approved quality assurance program, or work with you on any project involving industrial or mobile hydraulics and hydraulic systems. Gar Wood's technical competence has produced these additional products ■ single and tandem gear pumps ■ a complete line of components and valves ■ the revolutionary Variacs variable volume piston pump ■ Ultra-Static, the first packaged hydro-static drive system.

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Hydraulic Division • Wayne, Michigan

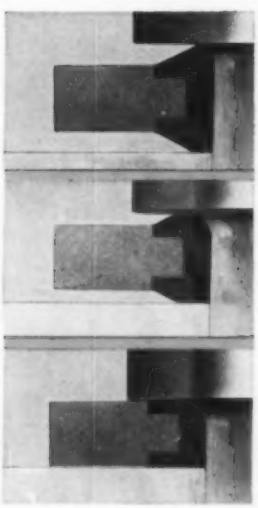
Gar Wood, inventors of the telescopic hoist, have engineered this latest model with over four inches of bronze bearing surface per sleeve. Seven-inch overlap per sleeve eliminates bell mouthing. Removable base facilitates service and repairing.

Check: Gar Wood's rugged air and oil mill cylinders may provide dimensional interchangeability with your present equipment. They come in a wide range of types and sizes, or can be made to your specifications. Standard hard rods and heavy-duty, all-steel construction insure long, dependable service.

introducing the NEW

Precision Para-seal®

Photographic enlargements show the flow of sealing member under various stages of compression.



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for face to face sealing

This new Precision engineered product reliably and inexpensively seals bolt heads, rivets, screws, flanges and flange fittings. It is priced so low that you can now afford to use a seal of this type in your production equipment.

FEATURES:

- 3 Point Sealing
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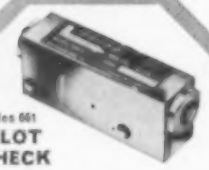

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Series 271
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Simple, positive, low-cost way to prevent cylinder creep due to leakage of spool valve. ¼" to ⅜" N.P.T.F., 3000 p.s.i.

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Smooth, positive control of negative loads. Cylinder speed proportioned to pump output. ½" and 1" N.P.T.F., 3000 p.s.i.

Simplify hydraulic system design while you get improved performance. Why settle for halfway measures when you can specify a Waterman valve *designed* for these and other special purposes?

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NEW LITERATURE

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TFE O-RINGS

Catalog has over 250 sizes of TFE O-rings which have high chemical stability, heat resistance and self-lubricating properties. Nominal and actual decimal dimensions and tolerances for ID and width; OD nominal only. Classified by SAE ARP-568 dash numbers; AN-6227 (packing) and AN-6230 (gasket) numbers are given where applicable. Prices for quantities up to 20,000. All sizes stocked. Price list P-1A.—*Chicago Gasket Co., Chicago.*

Circle **400** on Reader Service Card

FLOATING PISTON ACCUMULATORS

2000-psi to 5000-psi, single and double-shell accumulators with oil-volume 7.07 cubic inches to 43.7 gallons are shown in cutaway views. Operating temperatures from —40 F to 180 F. Dimensions, specifications, volume-pressure charts, 80 pages. Special seals for other than commercial SAE fluids. Special accumulators for 20,000-psi use. Auxiliary gas bottles, accumulator charging and gauging assemblies also covered.—*Superior Hydraulics Div., Superior Pipe Specialties Co., Cleveland.*

Circle **401** on Reader Service Card

ELECTRIC MOTORS

Everseal formulation, solid-cast encapsulation available on windings with random-wound coils, to 125-hp, 1800-rpm. Motors with form-wound coils (150-hp and larger) come with Everseal silicone-rubber insulation. Charts included state findings of continuous immersion (three month) tests for motors in various damaging reagents at 75 F. Torture-tests of sample stators under electric current and voltage surges are explained and diagrammed. Likewise heat-freeze tests from —40 F to 266 F, and thermal conductivity, water absorption, hardness, thermal cracking and flexibility tests. Catalog F-2034.—*U. S. Electrical Motors, Inc., Los Angeles.*

Circle **402** on Reader Service Card

TEMPERATURE CONTROLS

Smooth, silent temperature control from sub-zero to 450 F. Element utilizes materials which expand with temperature to force moulded synthetic rubber plug into reduced diameter piston guide. Extruding action multiplies piston movement which operates mechanical linkage, electric switch, etc. Return spring restores parts as element cools. Responds to fast temperature changes. Not affected by barometric pressure. Temperature-movement curves are given with a general explanation of construction and function. Bulletin 213-A.—*Detroit Controls, Div. American-Standard, Detroit.*

Circle **403** on Reader Service Card

INDICATING FILTER

An indicator on the filter body shows when cleaning is needed, and eventually indicates by-passing due to clogging if warning is ignored. Elements for filtration of 74- to 238-micron particles. Flow rates 0 to 120 gpm. Cutaway drawing shows all major parts. Mechanical indicators standard; electrical indicators optional. Magnetic filters optional. Bulletin 61-78.—*Vickers Inc., Div of Sperry Rand Corp., Detroit.*

Circle **404** on Reader Service Card

HEAT EXCHANGERS

Cooling within 2 degrees of cooling water; dew point as low as 20 F. Air-through-shell aftercoolers have ⅝" OD x 18 gauge metal

Continued on page 60

Circle **105** →

For YOUR cylinder requirements

T-J SALES and SERVICE ...COAST to COAST

Tomkins-Johnson Sales and Factory Service Engineers can offer you valuable assistance in the proper selection and use of any T-J cylinder to its proper power application, whether O.E.M. or replacement. They are also well qualified to assist your project engineers in the design phase of most all pneumatic or hydraulic power systems. T-J Sales and Service Engineers are located throughout the entire United States and Canada for immediate service. Contact your nearest T-J representative, or T-J direct.

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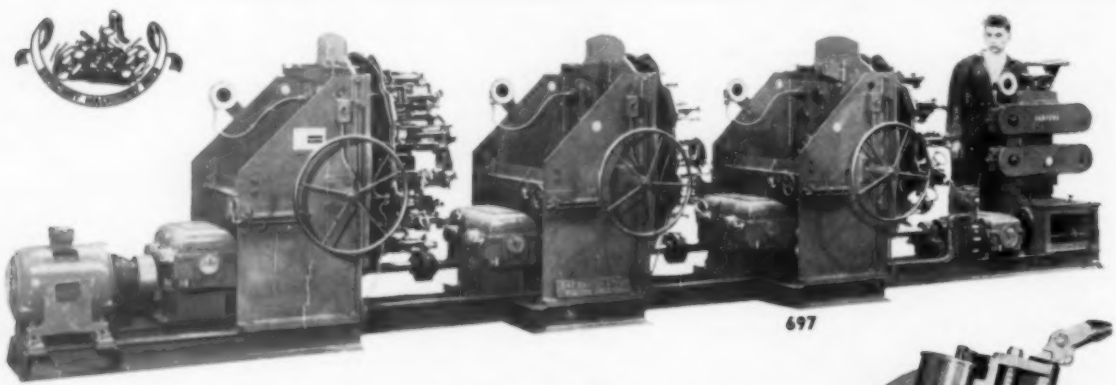
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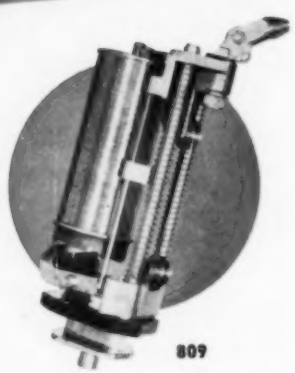
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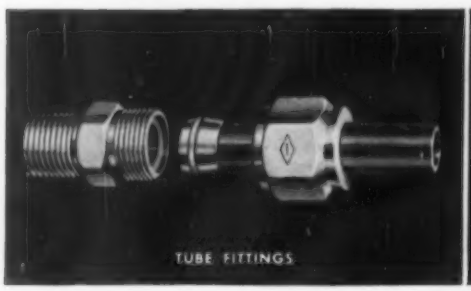
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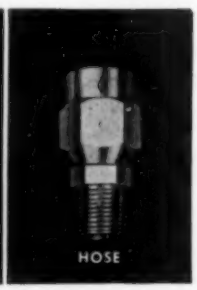
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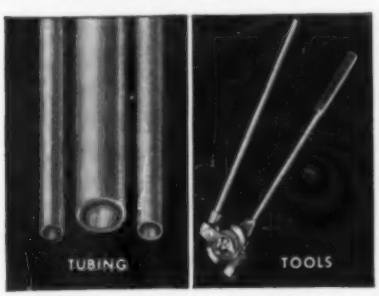

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NEW LITERATURE

out removing the body from the line) and McCannaflo (valve with one-piece bar stock body and end adapters) are shown. Sizes from ¼" to 12"; screwed, socket weld, and flanged end models for temperatures −150 F to 1000 F, pressures to 1000 psig, vacuum to 10^{-6} mm Hg. Standard body materials include carbon steel, stainless steel, bronze, aluminum, and solid PVC; others optional. Seat materials of Teflon, Buna-N, neoprene, and two new types: Graphitar seat for up to 1000 F service, and Fire-Seal with Teflon in machined metal secondary seats. Pneumatic operators are shown. Catalog 1200-A.—*Hills-McCanna Co., Carpentersville, Illinois.*

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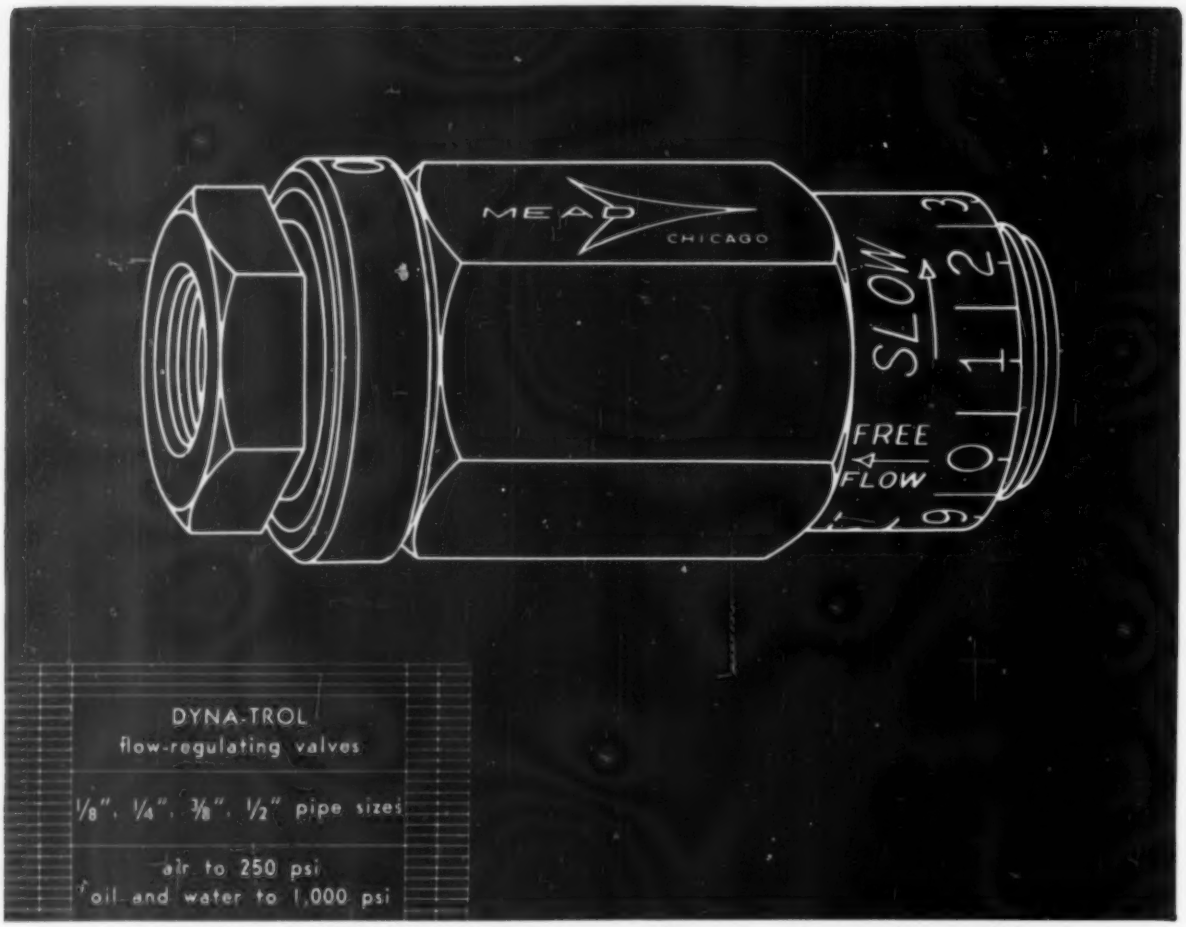
For more reviews of FREE LITERATURE turn to page 122.



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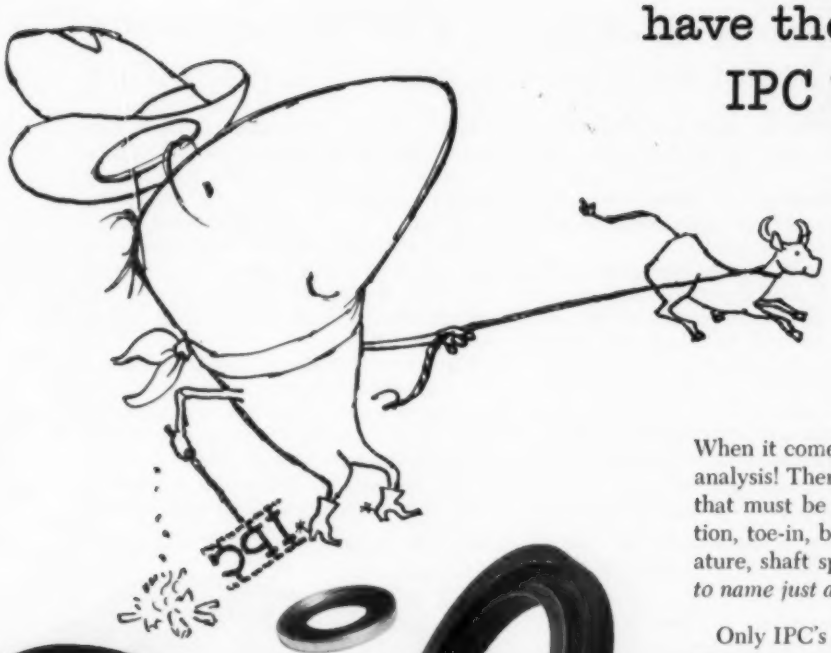

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Hydraulics & Pneumatics
DECEMBER 1961

AEROSPACE REPORT

Is fluid power keeping pace as technology moves to meet the problems of missiles, spacecraft, and ground support equipment? In the following pages of this issue, representatives of aerospace technology sum up the state of the fluid power art. Here are highlights from their remarks.

• **Flight Control**—The environment of space requires a whole new technology of flight control. Conventional aerodynamic surfaces are useless in the vacuum of space. Missile designers control direction of engine thrust during powered flight, and depend on jet reaction from small control nozzles during non-powered flight. Jet vanes or jetavators have been used for thrust vectoring. New developments are coming in secondary injection, in which fluid is squirted into the thrust nozzle from side orifices. This deflects the exhaust thrust.

Jet reaction systems are powered by either solid or liquid propellants. Solid propellants are good for one-shot, short duration systems. Liquid propellants give on-off and metering control for long duration flights. Integrated systems which include torque motor, metering valves, injectors, and thrust chamber in one package are the goal. Both pulse modulated and proportional controls are used; each has advantages in certain applications.

• **Contamination**—Better systems result from both a higher degree of cleanliness, and components with higher tolerance for contamination. In a field where little data was available, steps have been taken to establish ground rules for sampling techniques, cleanliness levels, filter testing. Much has been learned about manufacturing methods and maintenance techniques to produce clean systems and keep them operating. Filter designers recognize the requirements their products must meet: increasing pressures and temperatures (6000 psi systems in development, 2000 F for some hot gas systems), new fluids, and extreme impulse, surge and vibration.

• **Auxiliary Power Units**—Long-duration space travel brings new needs for power sources and control: higher energy fuels, possibly cryogenic hydrogen or oxygen . . . materials for higher temperatures, pyrolitic graphite is being tested for turbines at 5000 F . . . weight reduction . . . new energy sources like solar and nuclear turbogenerators. The trend is to direct conversion of energy to electricity for vehicle power including fluid power. Pump speeds are going up, 40,000 rpm is a goal, with variable displacement replacing fixed.

• **Reliability**—The reputation of hydraulics for long flights is not satisfactory. High temperature sealing is fast developing, but standards are

needed to evaluate new designs for general use. Pump design should concentrate on piston slipper failure and compensator oscillation. In servovalves, null shift and instability are limiting temperature to 500 F.

• **Gas Systems**—Rapid advances are being made in hot gas systems for auxiliary power, attitude control and short duration, low power flight controls. Future applications will be for secondary injection, thrust vector control systems . . . aerodynamic surface control of hypersonic and re-entry vehicles . . . and control in high radiation environments. Rotary motors with little fluid under compression are the most promising gas actuators. Under USAF development is an all-gas stabilization system with no electrical or electronic elements.

• **Ground Support Equipment**—Handling, test, and simulation equipment has developed along with flight vehicles. For ICBM's and space craft, GSE now accounts for 60 to 70% of total system cost. Development of support equipment to operate in atmospheres of other planets is gaining importance as our space exploration efforts advance.

. . . flight control of aerospace vehicles

• By **GEORGE R. KELLER**, *Manager, Special Products Section, Helipot Division of Beckman Instruments, Inc., Fullerton, Calif.*

GEORGE KELLER *was responsible for design of the hydraulic systems and power servomechanisms on the Navaho missiles and on E-7 autopilot. He has been awarded several patents on hydraulic and servo control devices.*

Author of many technical articles and the book Aircraft Hydraulic Design, *he was a civilian consultant to the Assistant Secretary of Defense and is a member of the Bureau of Naval Weapons BIMRAB subcommittee on the reliability of hydraulic components. He is chairman of SAE's subcommittee on missiles and space vehicles.*

The great difference between space and our gaseous atmosphere affects basic dynamics of vehicle control.

• **Environment Problems**—In space there are no atmospheric gases; however, there are spatial and time zones of severe radiation densities.

The vacuum of space is more a hardship on mechanical than on electrical devices.

- All moving mechanical devices must either be in pressurized and sealed areas, or provided with lubricants of extremely low vapor pressure, such as Teflon or molybdenum disulphide.
- Rubbing surfaces must be designed so that the formation of metallic oxides is not required for lubrication.
- Pressure transmission fluids must be completely contained.
- Film-forming mechanisms must not be exposed to the vacuum.
- All organic compounds must be formulated from completely non-volatile materials, or their exposure times must be sharply limited.
- Metals not receiving direct solar heat will not be temperature limited by ambient gases, but must be protected from embrittlement at very low temperatures.

Another effect of space vacuum is the hazard to personnel operating outside of pressurized, temperature-controlled areas. This hazard means that the maintenance and repair of mechanical elements exposed to the vacuum will be almost impossible, so this equipment cannot be allowed to fail.

Radiation problems stem from both the Van Allen radiation belts and from storms of charged particles emitted periodically by the sun. Eventually nuclear power plants may add another source of damaging radiation. Nuclear bombardment is damaging both to electronic equipment and to organic materials. Semiconductor circuitry must be heavily derated to minimize the effect of radiation particles. The only electronic alternate seems to be heavy, bulky magnetic amplifiers. Recently developed fluid computers—especially pneumatic computers having no moving parts—may well be the eventual optimum solution for computational elements of control systems.

Organic materials, particularly those composed of long polymeric chains, are greatly altered by both gamma rays and hard neutrons. Cross linking of the chains under bombardment causes hydraulic fluids, engine oils, and greases to undergo sharp viscosity changes. Many soon become solids. Obviously, control system materials must be carefully chosen to avoid these changes, or else suitable protection must be provided.

• **Flight Dynamics**—The absence of lift in space makes a great difference in flight control. When the pilot of an airplane moves his control stick or rudder pedals, he produces an immediate rotation of the aircraft in one or more of the three rotational axes. However, the long term effect of a control motion is a rate of turn or rate of climb. Lift both limits and supplements the effect of the control surface and alters a simple rotation of the airframe into a changed—or changing—flight direction.

In space flight, a controlling action which produces *rotation* of the flight vehicle does not alter the flight direction and speed (velocity vector). A space ship can be turned sideways or end-for-end without changing its flight path. In addition, once a rotation is started it will continue indefinitely, unless action is taken to counter it. The longer a rotational control is held on, the faster the rate of rotation.

These control differences mean that the pilot of an aerospace vehicle must have different control modes depending on whether he is operating in or out of the atmosphere. He must be able to transfer control smoothly from one mode to the other, or else compensating computational equipment must be installed between the pilot and the controlling elements.

• **Control Elements**—An airplane must be under control during almost all its flight. Any wind disturbance or instability of the aircraft or its control system results in a changed attitude and altered flight path. While stray rotational energy may alter the *attitude* of a spacecraft, it will not change the flight path. In fact, the altered attitude may not warrant correction. Spacecraft in inter-planetary transit, for example, might travel for days, months, or years without requiring attitude control action.

However, because of mechanical misalignments and basic system instabilities, a space ship's attitude control system must be active during powered flight. This includes boost out of a gravitational field, mid-path trajectory correction, and entry into a gravitational field or atmosphere. This control system must be constantly active for such vehicles as astronomical, geophysical, or weather satellites. "Snooper" space probes investigating other solar bodies must be attitude stabilized during their data collecting periods.

Fortunately, the basic theoretical nature of the controlling elements remains unchanged. A spacecraft control system diagram is the same as that for an airplane. The differences lie primarily in the elements represented by the motor block.

• **Control Attitude With Power**—When the space vehicle is operating under power (presumably, a chemical fueled rocket motor), attitude is controlled by varying the direction of the thrust vector. In the past, thrust vector has been controlled by deflecting the exhaust stream with jet vanes or jetavators, or by swivelling the thrust nozzles of the rocket engine. The deflected stream produces a rotational force moment around the vehicle's center of gravity as well as propulsive force. Recently there has been much interest in deflecting the exhaust stream by secondary injection. The supersonic exhaust stream is diverted by squirting fluid into the thrust nozzle from orifices in the sides. This blockage creates a diagonal shock wave which deflects the exhaust thrust.

• **Control Attitude Without Power**—During periods of coasting (free fall between planets or orbital flight around a gravitational field), there is no engine power for control. Any part of a space ship (including its occupants) which changes velocity in a direction which does *not* pass through the center of gravity of the space ship will produce a torque which will cause the space ship to rotate in the opposite direction.

In such a situation, reaction from gas jets or from acceleration of a mass is used to control the attitude of the space vehicle. Gas jets are used to orient the X-15 research vehicles and Mercury space capsules.

Mass reaction systems function according to the most basic law of angular motion:

$$T = I\alpha$$

where T = Torque
I = Polar moment of inertia
α = Angular acceleration

In its usual form, the mass recation system consists of three flywheels, one for each axis. They flywheels run at constant speed until control is needed. Slowing down or speeding up the flywheel then provides the reaction torque to rotate the airframe. In another form, flywheels precess gyroscopically to produce a reaction torque.

• **Directional Control**—A force such as rocket thrust or gravity is necessary for directional control. However, attitude control is usually necessary to obtain proper direction of rocket thrust. For instance, in free fall, *all* forward motion must be stopped in order for the space vehicle to turn 90 degrees.

Aerospace Report

. . . jet reaction systems for attitude control

• By DR. W. WAI CHAO,
Director of Research and Development, Vickers Inc., Div. of Sperry Rand Corp., Detroit, Michigan

Before joining Vickers in 1959, DR. CHAO *directed engineering on the second stage liquid rocket engine for the Discoverer Satellite and attitude control rocket systems for Project Mercury and the X-15 airplane.*

New attitude controls are supplementing or replacing conventional aerodynamic surfaces in high speed, high altitude aircraft and space vehicles. Jet reaction control systems are being used for these attitude controls. Current orbital satellites, the Mercury capsule, and the X-15 airplane are typical examples.

Figure 1 shows a typical arrangement where reaction jet nozzles are oriented for attitude correction in three planes: pitch, yaw, and roll. Opposed sets of nozzles are sequentially operated to produce a reaction thrust in response to an input signal. This thrust provides torque required to make attitude corrections.

• **Energy Sources**—Current reaction systems use both liquid propellants (including both bipropellants and monopropellants) and solid propellant as energy

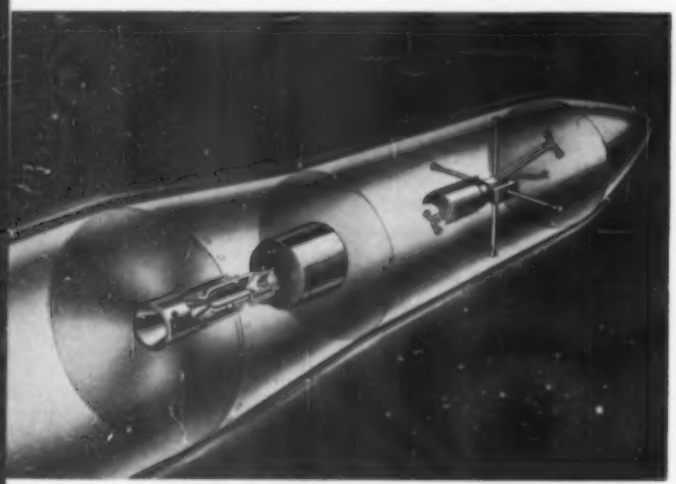


FIG. 1. JET NOZZLES provide thrust to control pitch, yaw, and roll.

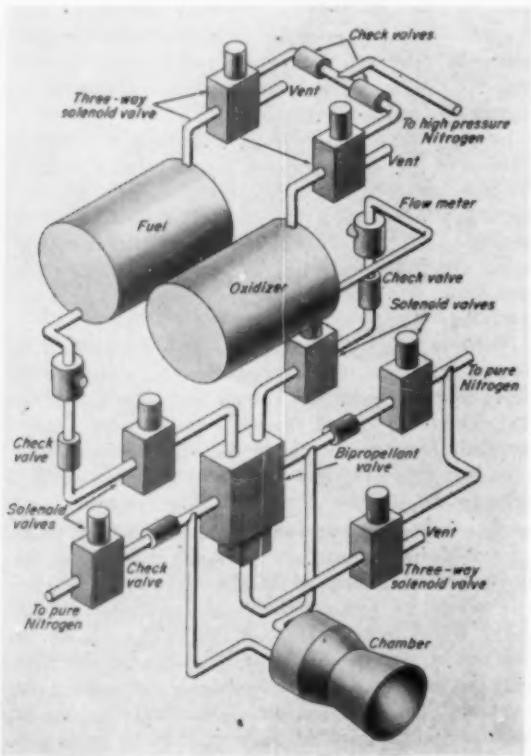


FIG. 2. BIPROPELLANT SYSTEM uses basic hydraulic components. Solenoid valves and check valves control fluid flow to the bipropellant valve.

sources. Each system has certain advantages depending upon the application.

• **Bi-propellant Systems**—Reaction systems using hypergolic and storable bipropellants have high specific impulse value and can be turned off and on or throttled. This is required for missions where long duration and intermittent operation is needed. Another advantage is that commercially available materials are used throughout the system, except for thrust chambers which are the only components exposed to high temperature gases.

Figure 2 shows a typical bipropellant circuit. Except for the thrust chamber, the system is basically hydraulic. The solenoid valves, check valves, tanks, and lines are hydraulic components. For this reason, experience in hydraulics is essential in the field of reaction controls.

• **Monopropellant Systems**—Figure 3 shows an experimental, hydrogen peroxide-powered, reaction control system. It includes a hydrogen peroxide reservoir, an integrating gyro and compensating network, and two nozzle pairs and servo valves. One pair of nozzles controls the pitch axis, the other controls yaw.

Pressurized hydrogen peroxide is introduced at the gyro-controlled servo valves. It passes over a silver catalyst bed in the thrust chambers, decomposing into a jet of steam and oxygen from the nozzles. Resulting reaction forces stabilize the bearing-mounted platform.

• **Solid Propellant Systems**—Solid propellants have been a primary power source in hot gas servo work, and they are suitable in reaction control systems for one-shot, short-duration applications. They are attractive for these applications because they are light, easy to handle, and reliable.

• **Design Approach**—Current use of auxiliary power packages on aircraft and missiles demonstrates the advantages of completely integrated systems. This same approach is used in reaction control systems for satellites and space vehicles. An integrated, reaction control rocket includes the torque motor or solenoid, metering valves, injectors, and thrust chamber in one compact package.

The liquid bipropellant, pulse-modulated rocket motor shown in Figure 4 was developed as an integrated package. For fast response, flow passages between the propellant valves and the combustor are minimized. The miniature, lightweight rocket reaches design thrust within a few milliseconds. It also withstands continuous pulse firings over a long period. Developments to date have covered a thrust range from 0.5 to 200 pounds. In addition to fast response, the integrated control rocket design also features low power input, high efficiency, and reliability.

• **Control Methods**—The two major controls for reaction systems are pulse-modulated and proportional.

The pulse-modulated system used on low thrust rockets uses solenoid valves which control through small increments of attitude correction. The system *taps* the vehicle into position by controlling thrust pulses rather than thrust level.

In the proportional system, the thrust from each pair of nozzles is proportional to the electrical signal to a torque motor. The system controls the thrust *level* which is applied continuously rather than pulsed. It is turned off and on as required.

Pulse-modulated and proportional systems both have advantages. Vehicle and mission requirements determine which is best for a particular application.

• **Future for Reaction Controls**—Although reaction control systems are now used extensively for attitude correction on satellites and space vehicles, other applications are possible in the future. For example, computations based on wind tunnel data indicate that jet thrust reaction can be increased considerably because of shock wave interaction phenomena under supersonic flight conditions.

Tests show that under certain conditions of atmospheric flight, reaction controls may be competitive with more conventional aerodynamic surface controls. Future high speed, manned aircraft may be equipped with both reaction controls and aerodynamic surface controls. Reaction controls are already on aircraft designed for both atmospheric and out-of-atmosphere flight, such as the X-15.

FIG. 3. MONOPROPELLANT SYSTEM uses servovalves to control flow to the nozzles. One set of nozzles controls pitch and the other controls yaw.

FIG. 4. INTEGRATED POWER PACKAGE for bipropellant system reaches design thrust in a few milliseconds. Short flow paths increase speed of response.

. . . gas system developments

• By **ALBERTUS E. SCHMIDLIN,** *Manager, Mechanical & Thermodynamics Laboratories, Walter Kidde & Company, Inc., Kidde Aero-Space Division, Belleville, N. J.*

ALBERTUS E. SCHMIDLIN *holds several patents on high pressure aircraft compressors, moisture separators, compressor unloaders and filters, and high pressure aircraft pneumatic systems. His experience has included design and development work on pressure reducers, dehydration equipment, relief valves, servo devices, and air compressors.*

Present systems use gas for power actuation and flight attitude stabilization. Systems will perform additional functions through integration. An integrated system provides double or triple duties for component and propellant, as well as reliability through redundancy at no weight penalty. A study of integrated cryogenic fueled, power generation, and environmental control systems was made for the Flight Accessories Laboratory at Wright Field. We studied the feasibility of combining space vehicle subsystems into one integrated system using cryogenic hydrogen and oxygen. Phase I of the design study shows that it is feasible to integrate propellant storage, environmental control, auxiliary power, and, for some cases, the reactive control systems.

This study revealed that a hybrid turbine (for example dual disc, 4 passes) was the optimum power drive for auxiliary power because it operates efficiently with a relatively low inlet pressure. Analog computer analyses show that system performance was adequate both during steady state and transient periods. Phase II is about to begin with the breadboard setup to verify results of Phase I.

• **Monopropellant Applications**—Reliability of proven equipment, is best illustrated by the NASA Scout vehicle. Thus far, 11 Scout missions with hydrogen peroxide reaction control systems have had a perfect score for the 2nd and 3rd stage reactive controls. This is an example of using a well known monopropellant rather than an exotic bipropellant. Although a bipropellant system is better for large systems with a total impulse greater than 10,000 lb-sec, peroxide is superior for lower total energy requirements. Its capabilities and limitations are well known, and present systems using hardware designed for peroxide have shown extremely high reliability.

Hydrogen peroxide is feasible for the vehicles of the future. It is well suited to the integrated system since it has life support capabilities as well as monopropellant energy characteristics. Also, it is a very favorable oxidizer to consider in a bipropellant, reaction control system. It can act as an oxidizer during the boost phase when large reactive forces are needed, and still be used as a monopropellant to provide lower thrust during glide and orbit.

• **Hot and Cold Gas Systems**—Cold gas systems for attitude control of a space vehicle become feasible in orbit where extremely small correcting forces are required. The environmental conditions here are extreme, but are being met by optimum use of existing materials in unique designs.

Hot gas systems have been developed for applications where actuators are required. Unfortunately, gas servo engineers are still asked to meet specifications written for hydraulic systems rather than the needs of the vehicle. Proper specifications could do much to achieve increased reliability, less weight, and smaller bulk. Control specifications should be expressed in terms of the basic needs of the vehicle, rather than an artificial interchangeability with incompressible fluid devices. Certain control concepts which are all mass

expulsion in nature for the entire flight eliminate this unfortunate situation.

• **Trend to Secondary Injection**—There will be a continuing trend toward an *all-fluid* control system for main engines. This is secondary injection which introduces a controlled flow of fluid into the rocket nozzle to vector the thrust force. Water table analysis confirms the feasibility of this approach. The ideal secondary injection system would use the *main* rocket gases for this purpose. Until such a system is developed, hot gases of lower energy level can be used at a sacrifice in thermodynamic performance, using existing equipment. Liquid injection can be employed with an added reduction in performance. It allows the use of conventional fluid components at normal temperature.

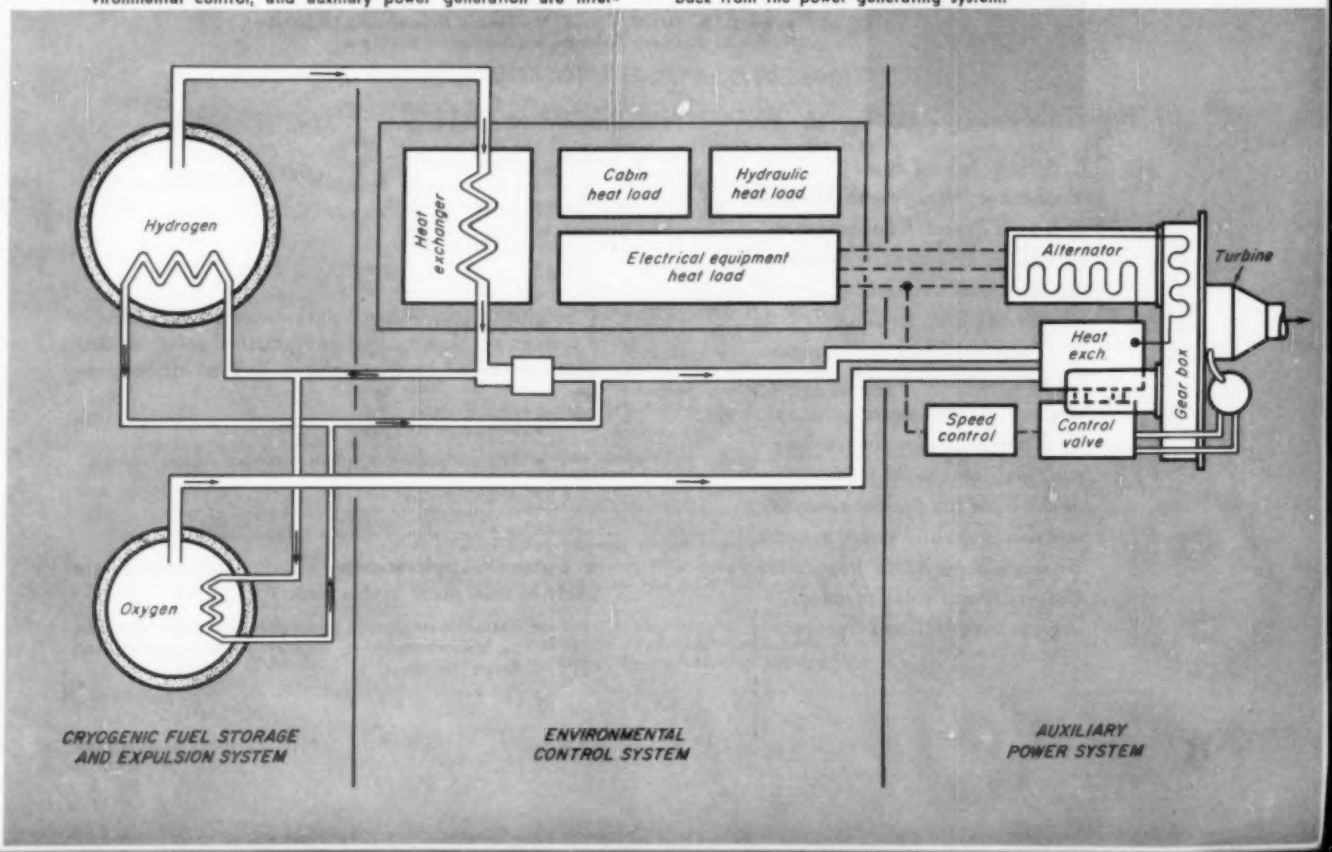
• **Gas System Components**—Much progress is being made on hardware for cold gas, attitude control systems. Valving is the main problem. In space, one faces high vacuum conditions of 10^{-10} mm of Hg, as well as temperatures between —250 F and 250 F. Valve designers have met this challenge by employing unique designs. Preliminary tests in a high vacuum chamber have shown that these designs are quite successful, even though they use some non-metallic materials.

Although there seems to be continued emphasis on faster and faster response times, present day valves for small, reactive control nozzles, with a shuttling time about one millisecond, seem to be entirely adequate. It is possible to design valving having a total opening time of about 50 to 100 microseconds. However, the gas dynamics expert will point out that in microseconds there is scarcely time for molecules to flow from the pressure source to the nozzle. If only a few molecules are required, these times are adequate. However, for a feasible gas expulsion thrust device, a one millisecond shuttling time would seem to meet the minimum pulse effort required.

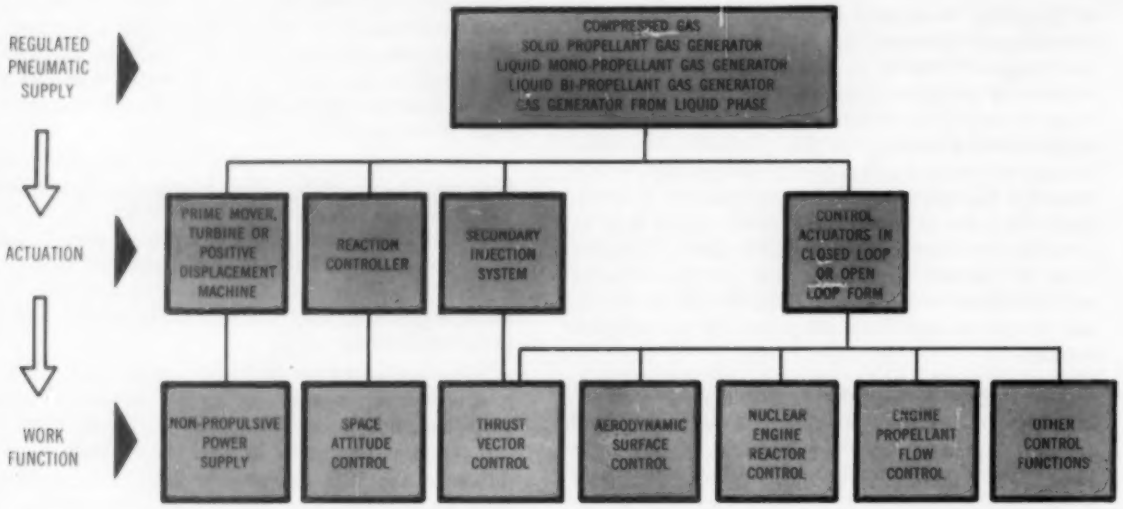
Launch and re-entry require equipment which can perform not only on high temperature fluids, but also within a high temperature ambient. Equipment for 1500 F to 2000 F ambient is being developed. A new, high temperature solenoid has operated for 39 hours at 1500 F with temperature cycling in between. The solenoid has sufficient force and stroke to pilot a high temperature thrust valve.

Optimum secondary injection systems will require control valving which can handle metalized, solid propellant, hot gases. These gases are above 6000 F, and create a very severe internal environment. In addition to the high temperature effects on working parts the hot gases introduce a severe combination of erosion, abrasion, and amalgamation in the valve body itself. Valves made of exotic metals last only a fraction of a second. However, present investigations with unique designs of ablative materials have shown that the valve body can withstand 17 seconds of testing under this abuse. Refined designs will improve the internal workings of the valve to meet these severe conditions.

INTEGRATED CRYOGENIC SYSTEM. Schematic shows how individual subsystems for propellant storage and expulsion, environmental control, and auxiliary power generation are interconnected. Heat feedback from the environmental control system influences the fuel expulsion system. Also, there is over-all feedback from the power generating system.



GENERALIZED AEROSPACE PNEUMATIC SYSTEMS



...future developments in aerospace pneumatic systems

• By **C. B. SUNG,** *Head, Mechanical Development Department, Bendix Research Laboratories, Southfield, Michigan*

C. B. SUNG *is head of the Mechanical Development Department of Bendix Research Laboratories. Prior to joining Bendix, he was affiliated with a consulting engineering firm. In China, Mr. Sung was Chief of Passenger Cars Depot of the Nanking-Shanghai Railway Systems Administration. He is currently directing various R&D programs in the fields of advanced fluid power controls and non-propulsive power systems. He received his BSME from Chiao-Tung University and holds advanced degress from MIT and Harvard.*

The growth of aerospace pneumatics started when it began providing unique and practical solutions that were unequalled by other means. Typical applications are:

- Non-propulsive power supplies.
- Attitude control of satellites and sub-orbital vehicles.
- Short duration and low power flight controls with requirements of long-term storage of power medium and minimum prelaunch preparation.

• **Future Applications**—Future applications are likely to take place in this general sequence:

- Extension of present applications for longer duration, higher efficiency or higher specific impulse, and better performance.

- Thrust vector control of rockets by secondary injection.
- Control functions of aerospace nuclear engines with little shielding between engine and controls.
- Aerodynamic surface control of hypersonic vehicles at relatively low altitudes and of re-entry vehicles.
- Control functions, other than propulsion controls, of aerospace nuclear-powered vehicles where radiation level is still significant.
- Control functions where environmental conditions are normal but direct use of available chemical propellants, cryogenic propellants, or pneumatic power sources result in simpler and lighter hardware.

• Major Problems to Solve—To make these potential applications a reality, the following major problem areas must be investigated and solved:

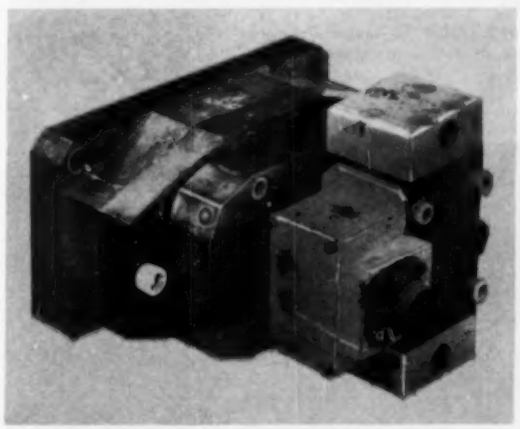
- Large thermal gradients and transients.
- Materials, bearings, lubricants, and seals for extreme environments.
- Low bulk modulus of gas.
- Contamination of solid propellant gases.
- Sensitivity of prepellants to severe environments.
- Reliability.

• Compensation for Low Gas Bulk Modulus—The best way to meet high performance requirements of most control systems is with a high speed, rotary pneumatic motor, driving through a high-ratio transmission. The rotary motor has a small volume of fluid under compression. This compensates for low bulk modulus. This approach gives a low reflected load impedance at the motor, making this type pneumatic control system practically insensitive to load characteristics.

In one test, an air motor controlled by a servovalve operated over a temperature range from 70 to 1200 F for 50 hours. Over 12 hours were between 1000 and 1200 F gas and metal temperatures.

A similar servomotor was tested with hydrogen over a metal temperature range of —100 to 600 F with a maximum thermal transient rate of 10 degrees per second. When operated as closed loop, position control systems with typical friction and inertia loads, both servomotors performed satisfactorily with a bandwidth greater than 10 cps and a resolution of about 0.1% of total displacement.

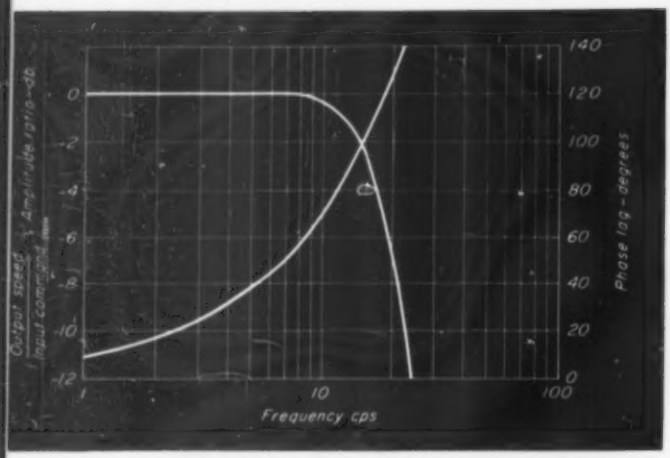
• Expansion Type Servomotor Performance—An expansion type pneumatic motor considerably reduces the gas consumption per unit power output. Recent experimental results have given information on two important questions of expansion type servomotor application: dynamic behavior and resolution capabil-



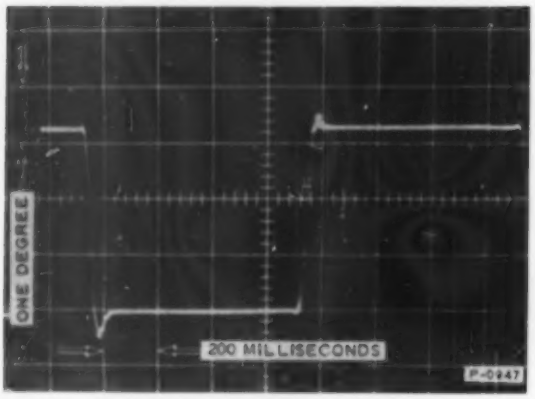
PNEUMATIC MOTOR is coupled to electro pneumatic servovalve for use in extreme temperature environments.

CRITICAL REQUIREMENTS OF AEROSPACE PNEUMATIC SYSTEMS

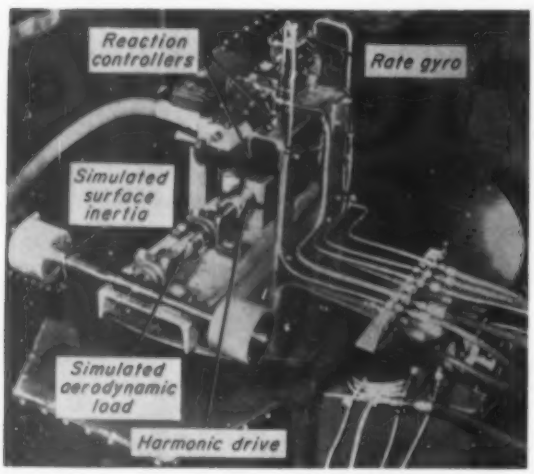
APPLICATIONS	TYPICAL CRITICAL REQUIREMENTS	TIMING IN FULFILLMENT
Non-propulsive power supply	0.1 to 0.15 kw-hr per lb of over-all system weight with reliability exceeding that of batteries	Immediately ahead
	0.15 to 0.3 kw-hr per lb. of over-all system weight with reliability approaching that of batteries	Within 3 years
Attitude control of satellites and space vehicles	For total impulses less than 1000 lb-sec., compressed inert gas system with leakage less than 1 lb per year over 1 to 3 years	Immediately ahead
	For total impulse above 1000 lb-sec and duration less than hours or days, systems utilizing propellant(s) with specific impulse at 150 to 200 sec	Immediately ahead
	For total impulse well above 5000 lb-sec., systems utilizing storable propellant(s) with specific impulse of about 300 sec, practically zero leakage over extended period, controllable thrust capability, and instant restart capability	Within 3 years
Short duration (minutes) flight and thrust vector controls	Low-power, on-off controls of extreme simplicity	Immediately ahead
	Reliability and performance comparable to, or better than those of electrohydraulic systems	Within 3 years
Thrust vector control by means of secondary injection	Cold gas injection	Immediately ahead
	Hot gas injection	Within 3 years
Nuclear propulsion controls	Capability for enduring extreme environments with reliability, performance, and over-all system weight siginficantly better than those of existing conventional electrohydraulic systems with shielding	Within 3 years
Extended duration aerodysamic surface control of low-altitude hypersonic or re-entry vehicles	Capability for enduring extreme environments with reliability, performance, and over-all system weight significantly better than those of existing conventional electrohydraulics systems with cooling	Within 5 years



OPEN LOOP frequency response of expansion type vane motor with electropneumatic servovalve.



MEASURED TRANSIENT RESPONSE of all-pneumatic aerodynamic surface control servo operating under simulated loads.



ALL-PNEUMATIC flight stabilization system used for performance testing has no electric or electronic components.

FUTURE DEVELOPMENTS

ity. The measured resolution of a rotary position servo using an expansion type vane motor is well within 0.2 degree. The maximum output speed of this servo is over 360 degrees per second and its output angular displacement is unlimited.

• **All Pneumatic System**—The Flight Control Laboratory of USAF Aeronautical Systems Division has sponsored research and development of a hot gas flight stabilization system using no electrical or electronic components. The purpose of the program is to develop systems for operation of several hours at temperatures beyond the tolerance of present electromechanical input and feedback transducers (1200 F or higher), without artificial cooling or special environment control. The system consists of a self-contained, liquid propellant hot gas generation subsystem serving as a central pneumatic supply for all power, sensing, and computing elements; a rate gyro and associated sensor; a computing network; a pair of thrust controllers using interstage feedback; and a rotary position servo for aerodynamic surface control.

• **Pneumatic Jets For Stabilization**—Pneumatic jets for stabilization and control are not limited to space vehicle applications. The Navy is investigating servo-jets for wide angle, aerospace radar antennas to reduce weight, improve performance and provide better long-term storage capability.

• **Lubricants For Extreme Environments**—The lack of satisfactory lubricants for rolling contact bearings has been a major limiting factor using radiation resistant and wide temperature range pneumatic systems. Polyphenyl ether based greases show promise for intermediate environment applications. However, solid lubricants are required for the most severe environments. Solid film lubricants have been developed recently and tested successfully.

Dynamic performance characteristics of solid film-lubricated, rolling contact bearings are similar to those of bearings lubricated with conventional greases. Their coefficient of friction is within the satisfactory range of 0.001 to 0.01 when operating at mean contact (Hertz) stresses up to 250,000 psi. However, as they wear out; they fail in a different way: their diametral clearance increases to a prohibitive tolerance in contrast to metal surface fatigue which is the usual form of rolling contact, bearing failure.

Bearings lubricated by this process have negligible wear up to about 100,000 revolutions at 1200 F. The lubricant then wears off and the wear rate increases very rapidly at about 250,000 revolutions. This general wear behavior is relatively unaffected whether the motion is continuous in one direction, cyclic, or at low or high speeds. The total angle of excursion is the primary wear parameter. Within one million test revolutions, the wear at room temperature is less than the resolution capability of the test apparatus.

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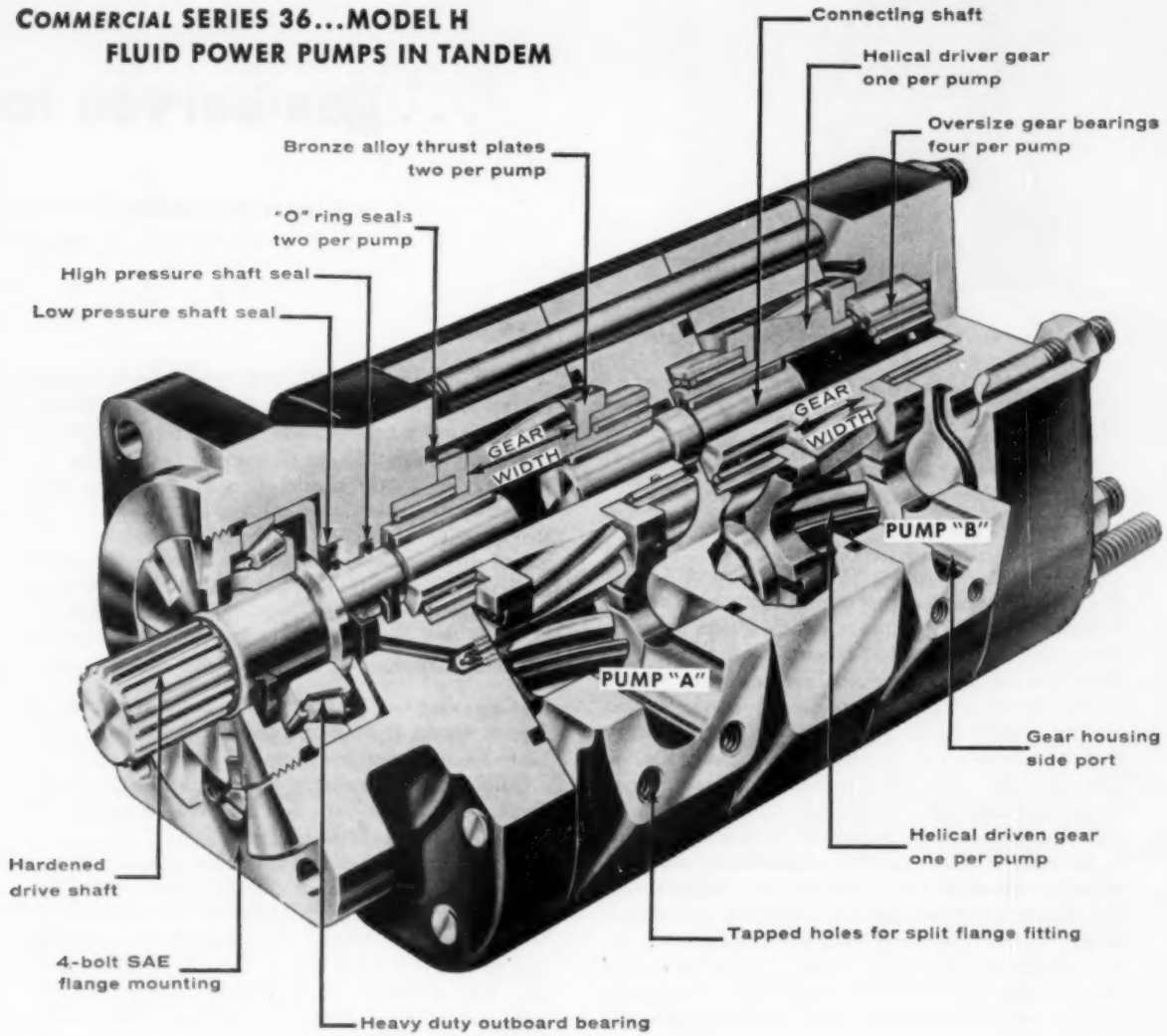
Connecting shaft
Helical driver gear one per pump
Oversize gear bearings four per pump
Bronze alloy thrust plates two per pump
"O" ring seals two per pump
High pressure shaft seal
Low pressure shaft seal
GEAR WIDTH
GEAR WIDTH
PUMP "B"
PUMP "A"
Gear housing side port
Helical driven gear one per pump
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. . . gas servos for

• By **WARD ZIMMERMAN**, *Project Engineer*
Weston Hydraulics Ltd., Subsidiary of

WARD ZIMMERMAN has been a project engineer at Weston since 1959 and is in charge of gas servo research. Prior to joining Weston, he was a research engineer at Boeing Aerospace Division doing design work on electrohydraulic servovalves and servo actuators for projects Bomarc, and Dynasoar.

The pressing need to reduce control component weight, increase reliability, improve vehicle system compatibility, and lower costs has led engineers to consider the direct use of gas products for aerospace vehicle control. Fewer components are needed in systems that directly convert stored gas energy to control energy than in systems using indirect methods. Generally, direct use of gas power for actuation will reduce system weight and eliminate less reliable components.

Recent developments in gas servos make it possible to use them in most applications previously using hydraulic servos. Gas power can not only actuate mass and spring type loads but it can provide jet reaction control force, impractical with hydraulic power. The type of gas and the way it is used to provide control moment, depends largely on missile and mission requirements. The versatility of gas power on aerospace vehicles is shown in the Table 1.

• **Control Moment**—There are two ways to provide control moment to aerospace vehicles using gas servos. The reaction nozzle provides a direct conversion of gas supply energy to control moments by using the expanding gas in the nozzle. This method gives high frequency response, but control moments are low for the quantity of gas used. The second method uses gas to drive a conventional piston actuator to control an aerodynamic surface. The actuator may also move a jetavator or gimbal an engine. The areodynamic surface and jetavator will give higher response of control moments than those of an engine gimbaling system.

• **Choosing Gas Supply**—The choice of gas supply for the system depends on gas consumption rate, duration of control requirements, and type of vehicle.

Solid propellants supply large quantities of gas for short periods. They are best for vehicles using solid propellant in the main engine.

Mono- or bi-propellants have these advantages over solid propellants: gas production rate can be controlled, operation time can be extended, and products of combustion are cleaner. In applications where main engine fuel is a lquid and the tank is pressurized, the gas servo can use the high pressure gas from the pressure source for actuation. The discharge from the control system will still be adequate to pressurize the

APPLICATION OF GAS POWER TO AEROSPACE VEHICLE CONTROL

TYPE OF MISSION	GAS SUPPLY	VEHICLE CONTROL METHOD	CONTROL OBJECTIVE
Short Range Missile	Solid Propellant	Reaction Jets Surface Control Thrust Vector Control	Flight Path Control
Long Range Missile or Boosters	Solid Propellant Tank Pressure Gas	Surface Control Thrust Vector	Flight Path Control
Secondary Missile Stages	Solid Propellant Tank Pressure Gas	Thrust Vector Reaction Jets	Flight Path Control
Orbiting Satellites	Stored Gas	Reaction Jets	Attitude Control
Re-entry Ballistic	Stored Gas	Reaction Jets	Attitude Control
Re-entry Glide Vehicle	Mono & Bi-Propellant	Reaction Jets Surface Control	Attitude Control Flight Path Control
Space Craft	Stored Gas Mono & Bi-Propellant	Reaction Jets	Attitude Control
Nuclear Power Aircraft	Compressor Bleed Gas	Surface Control	Flight Path Control

aerospace control

and **R. M. COX,** *Director of Research & Development*
Borg-Warner Corp., Van Nuys, Calif.

R. M. Cox *joined Weston Hydraulics in* 1952 *as a project engineer and was promoted to Director of Research and Development in* 1958. *He has guided Weston's research activities in gas servos, advanced hydraulic systems, and electronic controls for these advanced systems.*

tank. If long time storage and intermittent operations are required, a stored high pressure gas or liquified gas will be used.

• **Gas Control**—There are three ways to control the gas to reaction jets or actuation servos:

- Maximum effort or bang-bang control
- Time-modulated (T-M) control
- Proportional control

The choice of control method is up to the vehicle systems engineer. A choice between bang-bang or the other two control methods depends on the amount of output oscillation the vehicle can tolerate. Bang-bang and T-M controls involve some output limit cycle.

Valving for proportional control are more complex than for bang-bang of T-M. However, electronics are simpler for proportional controls than the other two. The resulting reliability differences do not appear to be significant.

These are some of the special problems associated with gas servos:

• **Valving for High Temperature Gases**—It is desirable to use the hottest possible gas because it weighs less for a given amount of control work. Valving now becomes a problem of materials choice. Design for operation life is a primary consideration if valve cost is to be reasonable. Materials chosen should provide only for the minimum required life. Applications using expendable components, as in ordnance type missiles, overdesigning a valve to exceed life requirements by even a few seconds increases unit cost many times over that of an optimum design. State-of-art materials provide short period operation with gases at 2000 to 3000 F.

• **Constant Gas Consumption**—For applications lasting more than five minutes, the constant consumption of solid propellants makes them less desirable than liquid or bi-propellant systems or gas storage systems. R & D is being conducted to overcome this inherent disadvantage. One proposed solution is a jell-like, semi-solid propellant whose rate of burning is varied by the rate at which the propellant is extruded into a combustion chamber. Some problems encountered: dynamics of fuel mass is a major obstacle because the unburned fuel must be accelerated to respond to changes in gas demand; and it is difficult to find a way to provide the force to extrude the fuel mass and sealing around it to prevent unwanted ignition or leakage. Other mechanical means are being developed to control the evolution of gas from solid propellants. Some success in regulating gas evolution to meet demand has been done chemically with mesa- and reverse mesa-burning propellants.

• **Lubricating Gas Actuators**—Lubrication in gas actuators has been provided by lubricant extrusion,[1] or the use of dissimilar materials. Actuators have operated dry up to 50 hours with no serious wear or malfunction due to friction. For typical expendable, solid propellant—driven servo actuators, a reasonable solution is to use dissimilar materials at bearing surfaces, and lubricate the actuator with a petroleum lubricant or a dry lubricant such as molybdenum di-sulphide. Lubrication will protect the systems during pre-flight check-out time. The dissimilar materials will ensure operation during the short period of flight.

• **Contamination**—The most satisfactory solution to gas contamination is to make servo components as insensitive as possible to dirty gas. An open center valve is less susceptible to contamination than a closed center valve, and is compatible with the constant burning rate of solid propellants. Considerable advances have been made in recent years to provide solid propellants which produce fairly clean gas. However, ignition charges are often found to leave a large deposit of particles that clog small clearances in systems that used unfiltered gas.[2]

• **Overcoming Gas Compressibility**—There are several ways to solve this problem:

- The actuator area may be oversized to require a smaller change in the pressure acting on the actuator piston. Unfortunately, this solution increases actuator size and weight as well as the gas power needed to meet output requirements.

- An irreversible drive, such as a high ratio gear reduction, may be used to multiply actuator torque. The friction of the drive mechanisms, their weight, and cost are factors which make them unsuitable in applications such as small, high-production, ordnance type missiles.[2]
- Mechanical compensation is possible with a hydraulic dashpot mechanism. Other methods include using a liquid metal in a semi-active damper; providing damping and static irriversibility; and using pressure feedback to provide damping. Auxiliary liquid devices add weight to the actuation system. Environmental limitations caused by temperature and radiation on fluids would reduce considerably the advantages of gas powered servos using this type damper.
- Recent developments to provide compensation for gas compressibility have greatly improved the performance of gas servos. Essentially, servo techniques provide lead components of the output or servo error signal to offset the lag component caused by gas compressibility. In experimental models compensated with acceleration and velocity feedback, servo response has been achieved which exceeds the blocked actuator/load natural frequency.

With the high positioning gains obtained, gas actuation servos can be considered for applications requiring irreversibility and load damping inherent to hydraulic servos. In some gas actuation servos a positioning gain provides full supply pressure across the actuator for an output of less than 1%. Promising developments indicate a value of 0.1% can be obtained.

Static reverse stiffness, K, of the gas servo actuator is:

$$K = \frac{100\,P_s\,A}{E\,S}$$

where: P_s = Gas supply pressure
A = Actuator area
E = Percent output stroke for which full supply pressure is obtained across actuator piston
S = Output stroke

The low limit of E depends on the use of high fidelity valve and electronic components. If hydraulics is used in the same actuator with only position feedback, as is conventional with state-of-art hydraulic servos, static reverse stiffness would be:

$$K = \frac{4\,B\,A}{S}$$

where: B = Fluid bulk modulus

For hydraulic servos operating at fluid temperatures of 400 F, we may assume a fluid bulk modulus of about 40,000 psi. The superiority of the compensated gas servo now becomes still greater. To compensate the hydraulic servo to accomplish better irreversibility, the complexity of the system would be greater than that of the gas servo. This would be due to added components such as pumps, pump drives, and hydraulic fluid.

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1. Reethof, G. "Analysis and Design of a Servo Motor Operating on High-Pressure Compressed Gas," Sc. D. Thesis, Dept. of Mechanical Engineering, M.I.T. 1955.
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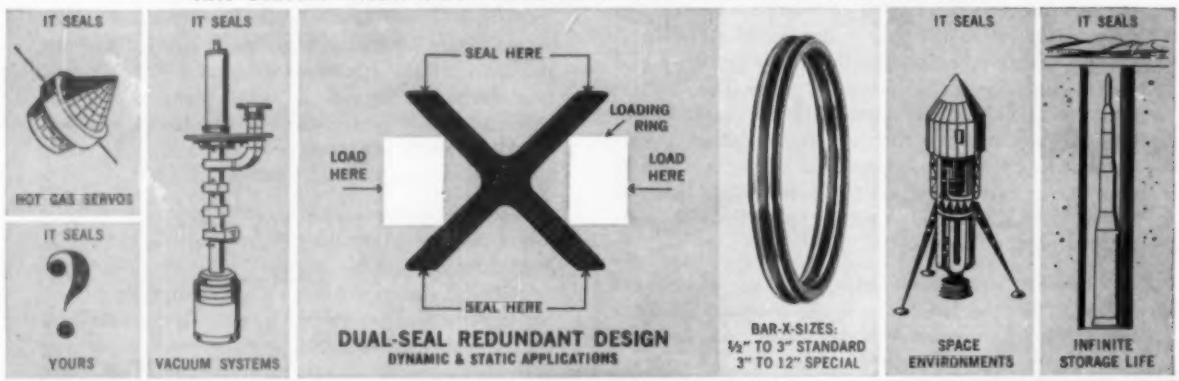

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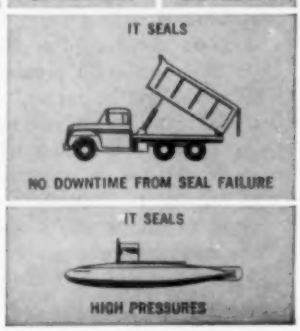

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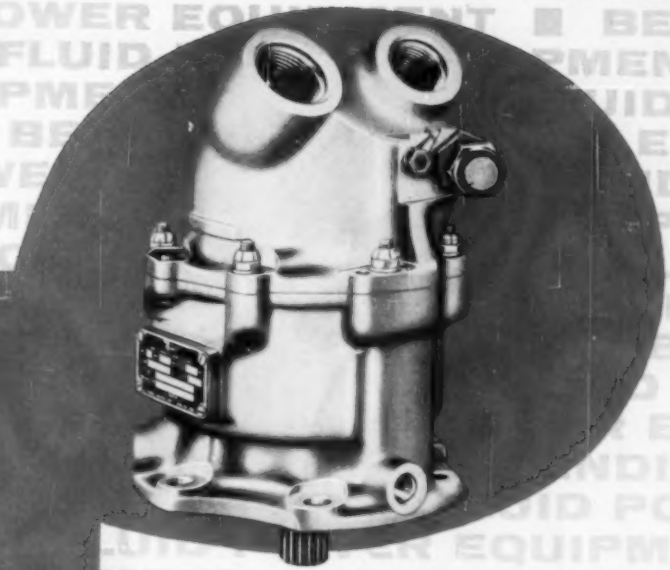

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. . . contamination and its control

• By P. S. KLEVEN, *Design Specialist, General Dynamics/Fort Worth, Texas*

P. S. KLEVEN *has been engaged in equipment and systems design and development of hydraulics, pneumatics, instrument and actuation vacuum, breathing oxygen, and other fluid media. Major responsibilities included aircraft projects C-87, B-36, FICON, YB-60, and B-58. He is a member of SAE Committee A-6 and chairman of its Filter Standards Panel*

Contamination in hydraulic fluids became an acute problem when hydraulic power was applied to high-response, high-resolution actuation such as flight controls in missiles and supersonic aircraft. This created a demand for miniaturized electrohydraulic servovalves to obtain maximum electrohydraulic gain. These miniature components in turn demand cleaner fluids.

Investigations showed that fluid contamination typical of and suitable for earlier systems was excessive for performance of sensitive, quick-acting servovalves and systems. To solve this problem quickly, it was necessary to concentrate on the control of fluid cleanliness and use existing valves and systems. From this has grown the technology of fluid contamination control.

Steady progress is being made to achieve satisfactory system operation in spite of contamination. Improvements and refinements have been developed to increase servo resistance to contamination, rather than only attempting to eliminate it. Some of these developments involve:

- dither
- clearance control
- manifolded filtration
- magnetic isolation
- signal power
- asymmetry
- feedback to first stage
- time modulation
- sequence filter grading
- erosion resistance
- system gain
- sizing

• **Degree of Contamination Control**—It is now probably possible to design systems and equipment that will perform satisfactorily with ordinary contamination corresponding to conventional, self-sustaining filtration. However, this is not recommended for general use because of excessive size and weight.

Design for maximum immunity to contamination is justified where system failure might endanger personnel, involve extreme cost, or peril vital missions. Less immunity can be tolerated if the only result of increased contamination is to degrade occasionaly noncritical systems. In some instances, contamination control should be used to improve system performance, and increase life even though control is not essential for minimum function.

• **Contamination Defined**—Contamination as an absolute is all foreign matter in a fluid. In practice, as considered here, contamination consists of particles that adversely affect system operation. An open problem is that of definition for characteristics of concern in addition to dimension, such as magnetic, abrasive, shape, cohesive, and adhesive properties.

• **Sources of contaminants**—Contaminants are either generated within, or creep in from the outside. A hydraulic system may become contaminated during its manufacture, operation, or maintenance. Special cases of contamination such as surface embedment and coating chips can be attributed to inadequate design, or manufacturing. Particle generation within the system may be caused by:

- abrasion at assembly
- flow erosion
- normal wear
- wear accelerated by contamination
- loss of surface coating
- fluid reaction with impurities
- biological organisms
- seal extrusion
- nuclear radiation
- agglomeration of smaller particles
- precipitations or deposits
- impede moving parts

• **Effects of Contamination**—Contaminants can affect systems in many ways. They may:

- plug orifices
- plug filters

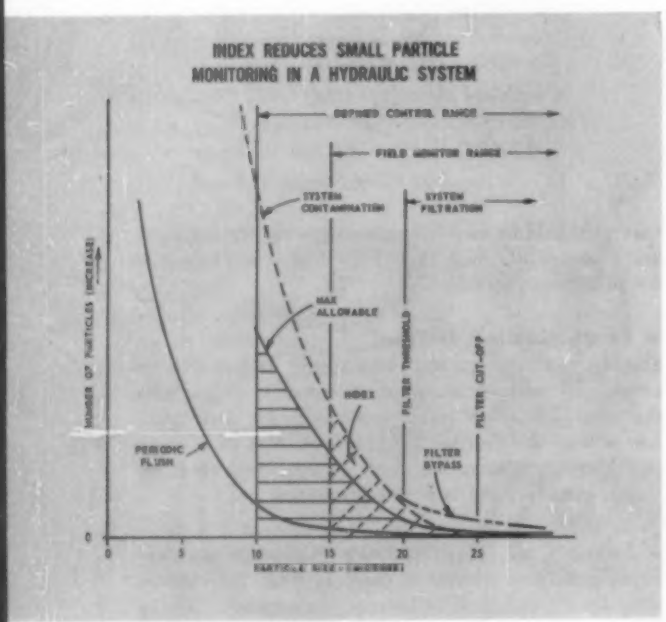
Continued on next page

CONTAMINATION AND ITS CONTROL

- wear or score high finish, sliding surfaces
- cause flow erosion
- upset clearance-flow pressure balances
- prevent proper valve sealing
- interfere with alignments
- modify fluid flow characteristics
- cause regulation hysteresis

The nature and use of individual systems govern how critical these may be. In high performance systems, for instance, contamination effects usually cause sticky action or poor servo performance. Contaminants wear valve metering edges. Besides spoiling servo dynamics, rounded edges increase leakage, heating and energy dissipation.

The Society of Automotive Engineers proposed ARP 219 is a procedure to determine relative effect



EFFECT OF CONTAMINATION on servo operation.

of synthetic contamination upon the life and function of components. However, it does not correlate these effects with specific control standards. Furthermore, though particle counts may exist in infinite varieties of distribution by size, there is no information on how variations in distribution affect system performance.

• **Standards for Contaminants**—Standards are needed to classify contaminants. A step was taken in ATC Report ARTC-28, *Specification for Contamination Control of Hydraulic Fluid*, prepared by the Aerospace Industries Association. It lists seven contamination level classes for particle number and weight. The seven count levels are essentially in progression, with fixed distributions between sizes. In most circumstances the correlation with actual conditions is poor. This will require deviations to avoid superfluous control efforts. A possibility to remedy this situation is to establish coding to permit selection of alternate distributions with equivalent performance. The weight criteria in ARTC-28 is nominally an index. Weights do not specify distribution but, because of volume relation, it puts an exponential penalty on increasing particle sizes. Contaminant criteria need development to complement the efforts for the most simple and effective control procedures. The index concept may eventually replace cross-section contaminant sampling.

For example, assume that for good operation, a system has filter transmissibility cut-off at 25 microns, near full transmissibility at 20 microns, and a periodic maintenance purge giving clean-up of fine particles down to about 10 microns. In such a system, an index criteria only for particles about 15 or 20 microns and larger would be representative of total contamination. Representation will be obtained since sampling dips into the smaller sizes below system integral filtration, thereby indicating fines concentration as well as presence of oversize particles. Still smaller size quantities will be implicit from typical distributon for the system. Although the pattern will be distorted by any filter relief valve by-pass, indication will be in safe direction.

At present, there are no standards for cleanliness of individual components. However, a National Aircraft Standards Committee specification is in an advance stage of preparation to set up such requirements. SAE's ARP 599 is a method to determine filter element cleanliness.

• **Evaluation Techniques**—Particle criteria require adequate detecting and measuring means. It would be easier to depend on self-sustaining system design or simple maintenance procedures instead, but usually some contamination monitoring is required. It is easy enough to detect large particles such as chips. The major problem is to devise methods for micronic particles. No procedure has yet been accepted as being accurate, quick, and convenient. SAE ARP 598 establishes a manual optical counting procedure for R & D purposes. This ARP has been valuable in validating findings between different laboratories. However, it requires a high degree of technical skill.

Field methods should give quick, repeatable numerical results. Tests should be run with reliable equipment, housed in ordinary facilities, using easy techniques. Numerical results are more useful for trouble analysis than go/no-go limits. Numerical records are also better for correlating system function and contamination.

Automatic electronic counters are being developed and tested. Preliminary results are encouraging. Counters will be expensive, but for many activities their speed and convenience will more than offset high initial costs. There is also a need for low cost portable equipment, even if it means sacrificing other characteristics. Low-cost, portable testing equipment is needed.

To implement particle weight criteria now requires accurate contaminant weighing to 0.1 mg. with a tare weight of about 70 mg. One aircraft company is doing this. The difficulty common to most methods is measuring small sizes. Index approach might be the answer.

• **Preventing Contamination**—Good design can prevent contaminants from entering a system. It can also prevent internally formed particles from spreading through the fluid. Careful analysis of a system will show every possible source of contamination.

In manufacturing, there is no substitute for painstaking cleanliness in keeping out large contaminants most apt to cause failures. Good design and workmanship also help prevent internal generation of particles.

A contamination-controlled class of MIL-H-5606 fluid is being produced. Usually any fluid charged into a system is pre-filtered at that time. Test units, such as aircraft ground mules, with non-bypass filtration finer than that of the aircraft itself prevent contaminants from being transferred from the test unit to the aircraft and overloading its filters.

The urgent problem is to obtain controlled practices which prevent contaminants from entering a system during the various stages of component and system assembly. Air Force Technical Order 00-25-203 establishes four classes of room cleanliness for various levels of contamination control. Such procedures, with proper certification and close supervision are needed for all component assembly.

• **Removing Contaminants**—Coarse contaminants are usually removed by disassembling the equipment. Flushing may require auxiliary external equipment or internal filters that protect critical parts or isolate sources of contamination. Self-Sustaining filtration in a vehicle is high desirable to reduce controls and maintenance. It may not be practical however, for filtering extreme fines. This will be made easier by the recent MIL-F-8815 standardization of absolute 15-micron filters. Magnetic filtration can be used, but it is best to avoid designs affected by magnetic particles. In designing a system, it is often necessary to choose between system safety and function. It is sometimes necessary to use filtration coarser that is ideal to minimize chances of filter plugging.

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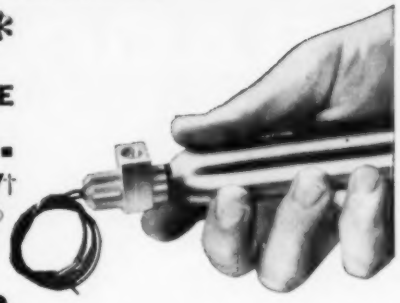

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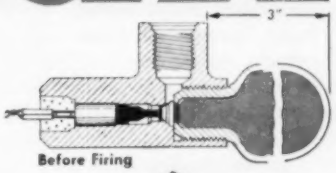

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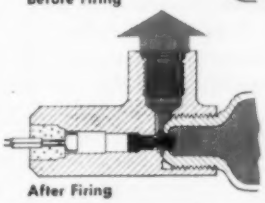
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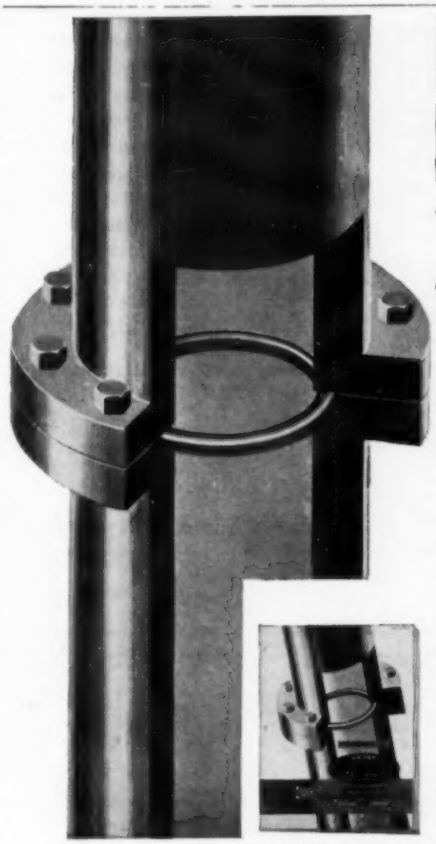

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Aerospace Report

. . . evaluating contamination

• By W. A. RIEHL, *Chief,*
General Chemistry Section George C. Marshall Space Flight Center
National Aeronautics & Space Administration, Huntsville, Alabama

The most widely accepted standard for evaluating contamination is Aeronautical Recommended Practice #598 prepared by the Society of Automotive Engineers. A recent survey of SAE's Contamination Control Panel shows that 17 of 42 companies are now using this method. These included 7 missile and space vehicle companies, 3 filter manufacturers, 3 fluid suppliers, 2 hardware manufacturers, and 2 government agencies. In addition, 15 laboratories have obtained check samples to investigate reliability of their analyses. Studies show that individual laboratory results should agree within 25% with SAE check slides, or between different laboratories using ARP 598 and exchanging separately prepared check slides.

A new procedure which is an extension of ARP 598 has been developed for sizing particles in the 1 to 5 micron range. Preliminary check-out tests show the results to be as reproducible as those obtained when sizing particles above 10 microns, using ARP 598. The new procedure, which incorporates minor technique changes is being prepared for release.

Because 1 micron is extremely close to the theoretical resolving power of optical microscopes, the sizing range will be changed to the 2.5 to 5-micron range. To improve count reproducibility, more efficient microscopic sizing techniques (globe and circle reticules) are being investigated. Microscopes also may be modified to keep the size of the globe or circle constant for various cut-off sizes (10, 25, 50 microns or more) as magnification is changed.

Many empirical or patch tests are used for production control or field use. Investigations are underway to establish reliability of go/no-go findings based solely on counts in the larger particle size ranges, 50 microns and over. If we can show that these evaluations agree with those based on total counts (over 10 microns) this would give us a quick and simple count method for field use. However, initial studies show that accurate counting of all particles over 50 microns would require undue equipment and time. It would be easier to count particles over 100 microns, but the small number of particles in this range would make the evaluation unreliable.

• **Sampling Techniques**—Studies are being made to establish the effects of sampling techniques such as isokinetic sampling, minimum flushing volumes, and sampling valves. A recent investigation showed that variations in sampling techniques caused particle counts to decrease appreciably until the valve and line were flushed with at least 300 ml of fluid.

Automatic counters are being used more widely. One instrument based on electrical conductivity is a valuable tool to measure large numbers of samples on a production basis. Two methods are being used to monitor flowing contamination with the system in operation. One is based on light absorption and gives results within 10 minutes. (H&P August 1961, p. 66). The other is based on ultrasonic beam reflection and provides either a continuous signal or individual counts within 10 seconds. Extensive reliability and statistical tests recently completed at Franklin Institute showed definite correlations between results from the ultrasonic instruments and those based on ARP 598.

• **Cleaning Filter Elements**—Contamination on the downstream side of filter elements is flushed directly into the servovalve when the system is started. Breaking in elements by exposing them to table or missile-firing type vibration has not reduced downstream contamination appreciably. The most effective and expedient way to clean the filters is to flush them with

CONTAMINATION LEVELS

Size Range (Microns)	Required Magnification	Class						
		0	1	2	3	4	5	6
2½-5	200 x	←			Pending			→
5-10	200 x	2700	4600	9700	24,000	32,000	87,000	128,000
10-25	100 x	670	1340	2680	5360	10,700	21,400	42,500
25-50	100 x	93	210	380	780	1510	3130	6500
50-100	50 x	16	28	56	110	225	430	1000
Over 100 (including fibers)	50 x	1	3	5	11	21	41	92

WILBUR RIEHL *has been engaged in contamination control in hydraulic and propellant systems since 1957 in conjunction with development of the Jupiter missile and Juno II and Saturn space vehicles. Riehl has been a member of the Contamination Control Panel of SAE since 1958, and chairman of a sub-panel which developed proposed ARP 599, "A Dynamic Test Procedure for Determining the Downstream Contamination of Filter Elements."*

pre-filtered solvents in a high-intensity ultrasonic bath. SAE ARP 599 for determining filter element cleanliness was developed, checked, and is now being processed for issue by the SAE.

• **Cleanliness Levels**—Considerable progress has been made to establish cleanliness classification levels. Three contamination control groups, representing SAE, American Society for Testing Materials, and Aerospace Industries Associates, who are working on this project agree that seven levels should be established as classes 0 through 6, with maximum particle counts doubling with each higher level. Final joint acceptance of these size ranges must still be settled, but the table shows a compromise approved by SAE and being considered by the other two groups.

To lessen the effect of size distribution differences when assigning a class level to a particle count, the count in one size range is allowed to be up to twice as high as the specified limit. If one or more counts are greater than twice as high as the limit in a given level, selection is made solely on the basis of the highest count.

The figures are based on analysis using ARP 598. To use these classifications properly, reliability of the particular analysis method used must be checked against standard check slides before comparing the results with this table.

Proper use of these levels should prove a significant step in reducing the confusion in contamination technology. These count levels provide an industry-wide tool to express fluid cleanliness in simple terms.

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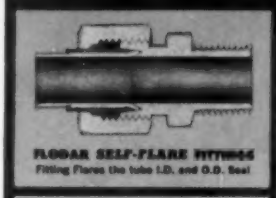
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. . . filter design for aerospace systems

• By H. L. WHEELER
Executive Assistant
Bendix Filter Division, The Bendix Corp.
Madison Heights, Michigan

H. L. WHEELER *joined the Jet Propulsion Laboratory of California Institute of Technology in* 1945, *where he developed processes for manufacturing porous metals by powder-metallurgy methods. He did R &D on controlled porosity and special alloy porous metals, and developed the wound wire process for fabricating porous metals. Mr. Wheeler has a B.A. in physics from Stanford and has served on the SAE A-6 subcommittee on filter contamination.*

Missile and aircraft filters must work efficiently over long periods of severe vibration and flow pulsation. Accelerations of 100 g's and system pressure surges from 0 to 3000 psi can be expected. Temperatures encountered range from those of liquified gas, below —300 F, to those of the discharge gas of a solid propellant rocket motor, above 2000 F.

More precise and delicate servomechanisms, a demand for more reliable long range missiles and space vehicles, higher operating temperatures and pressures, and wider use of high temperature pneumatics all point to more stringent requirements for filtering.

• **Performance Requirements**—Increased pressure seems to be the trend in aerospace fluid power systems. Aircraft and missile systems now operate at pressures of 3000 psi or higher. The hydraulic system on the B-70 bomber will have an operating pressure of 4000 psi; 6000-psi systems are also on the boards. Pneumatic control and pressure charging systems are already in use at pressures as high as 6000 psi.

High operating pressures frequently change both density and viscosity of highly compounded fluids. For example, viscosity of MIL-H-5606 increases 50% between 0 and 3000 psi. Such changes can not be ignored when designing a filtering system.

Burst pressure for the entire filter assembly is usually twice operating pressure for airborne applications, and four times for ground installations. Leaks or housing deformation should show up at proof pressure, usually 150% of operating pressure.

Pressure drop across a filter depends on flow rate. In well designed filters, pressure drop caused by a clean element media should be a small part of the pressure drop across the filter, and pressure drop across the filter assembly should be small compared to system pressure. A high pressure drop generally leads to high fluid velocities and low filter efficiency.

Because filter volume and weight must be small, aircraft and missile designers often try to force more fluid through the filter than it can handle satisfactorily. The high fluid velocities drive contaminants through the filter, lowering its efficiency.

Flow rates in airborne hydraulic filters vary from as little as 0.1 gpm in small actuating valves to as much as 270 gpm in the main supply system of the B-70.

• **Filter Rating**—Filter efficiency is its effectiveness in removing particles above a certain size from fluid carrying a known contaminant. It is a dynamic factor and depends partly on the fluid velocity, filter media, contamination, and whether there are surges and vibration in the system. Measuring efficiency is surprisingly difficult because of the problems in obtaining representative laboratory contaminants which can be readily identifiable. Furthermore, it is difficult to reproduce the dynamic conditions under which the filter will operate in aircraft and missile service. Aircraft and missile specifications usually require 95% or better efficiency from two microns up. The actual micronic rating depends on system requirements.

The dirt load a filter must carry without excessive pressure drop is related to flow rate. Specification MIL-F-5504B, for example, specifies no more than 40 psi drop with the addition of 0.10, 0.14, 0.65, and 1.00 grams of fine AC dust with a flow rate of ½, 3, 6, and 12 gpm respectively.

Under severe vibrations and pressure surges, filters tend to shed minute particles of media and generate internal contamination. This is called media migration. Organic media, such as paper, migrate extensively. Sintered powder migrates less. Wire media migrate the least. Media migration specifications come under system cleanliness. Some specifications call for zero migration under any operating condition. This is impossible to achieve.

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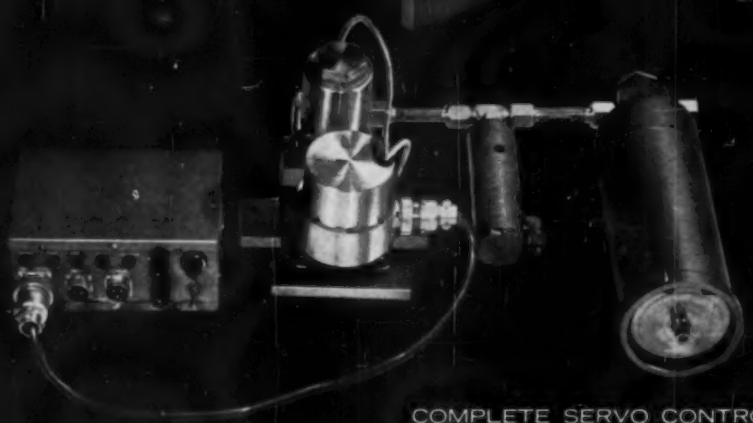

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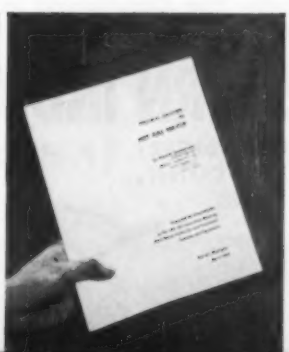

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Typical performance information on these units is given in a table below. For specific applications, consult the Eastern sales department for expected performance data.

2100 SERIES PERFORMANCE TABLE

	PRESS.	P. S. I.	200	1000	200	1000	200	1000
MODEL	SPEED	R. P. M.	400	400	2000	2000	3450	3450
2104	FLOW	G. P. M.	.5	.7	1.9	2.2	3.3	3.8
	TORQUE	IN LBS.	5	30	5	30	5	30
	PRESS.	P. S. I.	200	1000	200	1000	200	1000
MODEL	SPEED	R. P. M.	400	400	2050	2000	3450	3450
2107	FLOW	G. P. M.	.9	1.2	3.4	3.8	5.6	6.6
	TORQUE	IN LBS.	5	52	5	52	5	52

2700 SERIES

	PRESS.	P. S. I.	200	1000	200	1000	200	1000
MODEL	SPEED	R. P. M.	200	200	1000	1000	1750	1750
2708	FLOW	G. P. M.	.9	1.7	4.1	4.9	7.2	8.0
	TORQUE	FT. LBS.	1.1	10.9	1.1	10.9	1.1	10.9
	PRESS.	P. S. I.	200	1000	200	1000	200	1000
MODEL	SPEED	R. P. M.	200	200	1000	1000	1750	1750
2711	FLOW	G. P. M.	1.2	2.2	5.7	6.7	9.9	10.9
	TORQUE	FT. LBS.	1.5	14.6	1.5	14.6	1.5	14.6

For full information on Eastern fluid motors or hydraulic pumps, write for Bulletin 810 — or consult your Eastern sales engineer.

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PUMP DIVISION

FILTER DESIGN

• **Filter Media Application**—The operating temperatures of the majority of filters on manned aircraft hydraulic and lubrication systems fall within the range of —65 to 300 F, using such fluids as mineral based MIL-H-5606A diester based MIL-L-7808, or silicate ester fluids OS-45. In missiles and certain high performance aircraft, operating temperatures are higher and require using silicate ester fluids good to 500 F or silicone based fluids good to 700 F. At the present time, 1000 F systems are under development. Missile pneumatic actuating systems, where the source of hot gas is the exhaust product of solid propellant combustion, may reach temperatures in excess of 2000 F. Aircraft pneumatic systems operate at more moderate temperatures, usually under 500 F.

In addition to the foregoing criteria, there is a general requirement for all aircraft and missile filters to withstand extreme impulse, surge, and vibration without impairing the functional integrity of the filter. Aircraft and missile filter assemblies are frequently specified to withstand impact accelerations up to 100 g's and continuous vibration at resonant frequencies up to 50 g's. The same filters must also withstand pressure surges from zero to full system pressure for 100,000 or more cycles without failure of either the case or element. These requirements often call for increased cross sections and the exclusion of stress raisers such as small internal radii and grooves. This must be done at the expense of added weight.

• **Materials**—Strength-weight and environmental requirements rule out all metals except stainless steels and high strength aluminum alloys. Aluminum alloys are useful only for low to moderate temperatures under noncorrosive conditions.

The filtration of gases and liquids above 300 F requires stainless steels or superalloys. Below 1000 F, heat treatable, semi-austenitic grades have remarkable tensile properties and approximately the same corrosion resistance characteristics as AISI 18-8 type metals. Above 600 F the strength of these materials begins to drop rapidly, and above 1000 F they show very little advantage over more common 18-8 stainless steels.

CHARLES J. CASALEGGI *started his career with Purolator Products eight years ago as a project engineer. He has held various positions in the company's laboratory and engineering groups including supervision of aircraft filter design. He was recently appointed Staff Engineer in charge of product design and laboratory test engineering.*

. . . filtration requirements and developments

• By **CHARLES J. CASALEGGI**
Staff Engineer,
Purolator Products, Inc., Rahway, N. J.

Recent emphasis in filter development has been in these areas:

A filter media with more uniform pore distribution for more accurate control of the largest contaminants it passes.

A media for high temperatures of future control systems.

Smaller and lighter filters.

Filters to withstand the shock and vibration forces of space flight.

Filter elements that withstand differential pressures equal to pump rated pressure. This eliminates a bypass valve which allows contamination to pass downstream from the filter when the valve opens. The bypass valve would open during low temperature starting, when flow surges occurred and when the element became contaminated.

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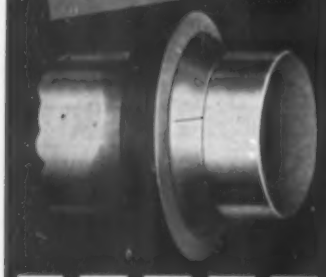

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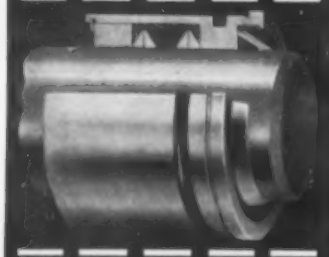

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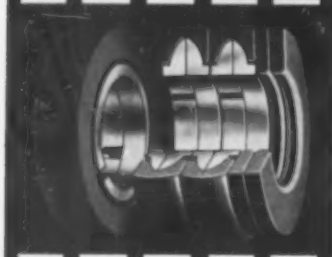

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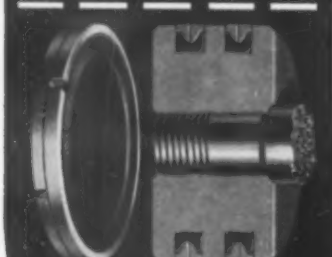

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FILTRATION REQUIREMENTS AND DEVELOPMENTS

• **Future Filtering Problems**—These are the development areas of filtering future aerospace systems:

To protect components machined to very close tolerances it will be necessary to design more efficient and positive filters for submicronic particle ranges.

Fluids other than conventional hydraulic fluids will have to be used at higher temperatures of space flights. Silphenylenes, polyphenyl ethers, liquid metals, high temperature air and hot gas systems are all being evaluated for future use. Filter and sealing materials are now being developed for them.

The environment in which future control systems operate will require stronger filters. This will be especially true for systems exposed to higher fluid and ambient temperatures and higher pressures.

Filters for advanced systems will probably be more expensive, and it will be uneconomical to discard a used element and replace it with a new one. The filter industry is trying to develop cleaning methods to make filters reusable.

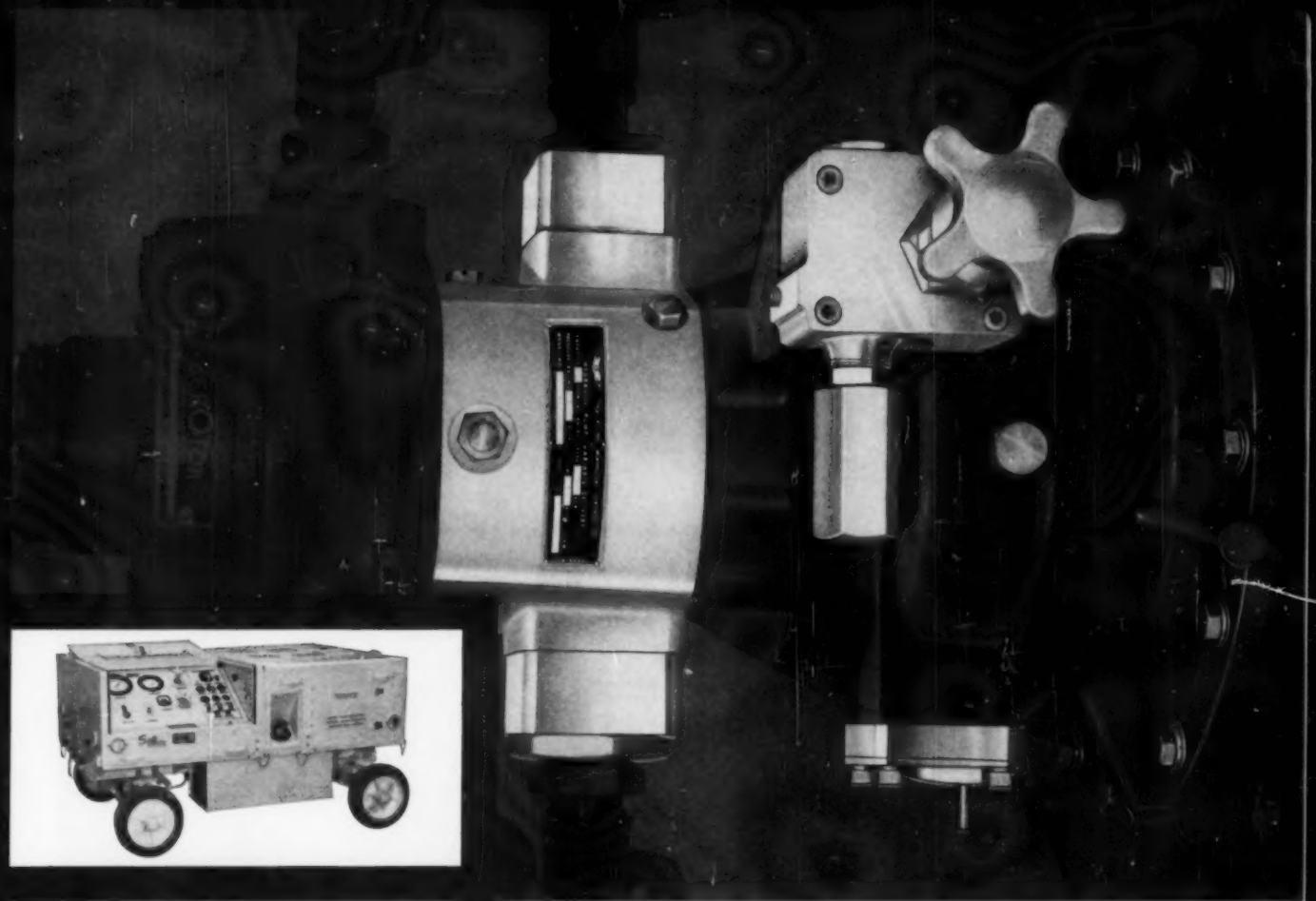
Dirt always plagues production operations. In filter manufacturing, there is a certain amount of built-in dirt on both the intake and outlet sides of a filter element. Dirt on the intake side of the filter must be removed before final installation, or these particles will enter the fluid stream and be forced into the very components which the filters should protect. Filter manufacturers are cleaning filter components before assembly, assembling the filters in clean, atmosphere-controlled rooms, and improving flushing and cleaning operations on completed units.

There are other difficulties in supplying a clean fluid to the components in a hydraulic system which have a vital effect on filter performance. For example, poor manufacture and assembly of components introduces large amount of contaminants in the hydraulic system. Contaminated fluids may be used to fill the system, and poor maintenance practices add contaminants to the fluid.

These sources of dirt shorten filter life or require larger and heavier filters. Look for improved housekeeping practices, better control of original fluid cleanliness, and more emphasis on flushing and filling systems as part of ground handling control.

ANNUAL INDEX

Send for your copy of the 1961 index to articles which have appeared in Hydraulics & Pneumatics this year.



Kline THRU-TORQ Pump driving a boost pump is mounted on Model AHT-54A Sun Test Stand. Hydraulic lines have been removed for clarity.

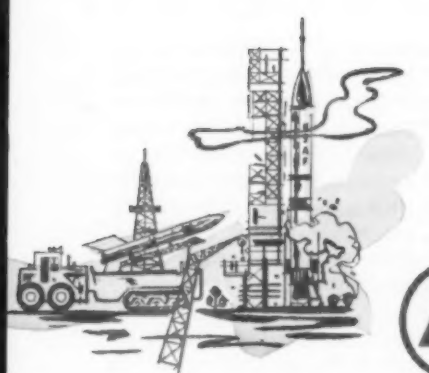
Sun Electric Corporation realizes maximum hydraulic efficiency with

Kline Hydraulic Pumps

The Kline Thru-Torq Pump, shown here, is direct engine mounted, thereby eliminating gear boxes for both the high pressure pump and the low pressure boost pump. Because of the substantial resultant savings in money, space and weight, Sun Electric Corporation, a leading designer and builder of hydraulic test stands, selected the efficient and versatile Kline Thru-Torq pumps for their model AHT-54A.

In addition to test stand uses, Kline Pumps provide flexibility and true simulations in other aircraft and missile ground support applications. No other pumps in the 3000-5000 psi range are so compatible with existing aircraft hydraulic systems.

Kline pumps are designed and built for a wide range of applications in many types of industrial and OEM applications. Contact your local Kline distributor or write direct for detailed information.



KLINE HYDRAULICS

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JOSEPH BENDERSKY *has 11 years experience with GE in aerodynamic turbine design and research on APU's. He developed air turbine drives for alternators and hydraulic pumps in the B-52. For rocket vehicles he developed turbines powered by hot gases from solid and liquid propellants. He was responsible for the fluid dynamic design of the APU's on the X-15 and the turbodrives on the Centaur. He is a member of Tau Beta Pi, IAS, and SAE Committee A-9.*

. . . accessory power

• By **JOSEPH BENDERSKY**, *Manager-Preliminary Design, Aircraft*

Is our ability to meet the accessory power requirements of the longer range, manned and unmanned vehicles proposed for lunar exploration and beyond, keeping pace with the requirements? The power level in such vehicles is high, and the duration of the mission is days and weeks rather than minutes and seconds. Figure 2 forecasts future Air Force missions, as described by G. W. Sherman of the USAF Air Research and Development Command. In addition to power, reliability requirements will be extremely difficult to meet, particularly in manned vehicles.

Now, and for some time to come, however, the three general methods of providing fluid power are a pressurized reservoir, an APU mechanically driving a pump, or electrical power energizing a motor-pump.

The pressurized reservoir is obviously for short duration, one-shot vehicles. Also a reservoir may be pressurized by a gas generator unit that burns a solid propellant to pressurize the hydraulic system. The gas generator eliminates many storage problems because the hydraulic system is under pressure only when in use. Gas servo systems also fall into this short duration category. They will reduce weight and often offer certain advantages in high temperature and high radiation environments.

Accessory power is usually derived from a small turbine engine taking its energy from some monopropellant such as hydrogen peroxide or hydrazine. The engine, in turn, drives a hydraulic pump that supplies the vehicle system.

• **Direct Energy Conversion**—The major competitors of the turbine APU are the new methods of direct energy conversion, thermoelectric and thermionic converters and fuel cells. The latter are attractive because efficiency is not limited by the Carnot cycle.

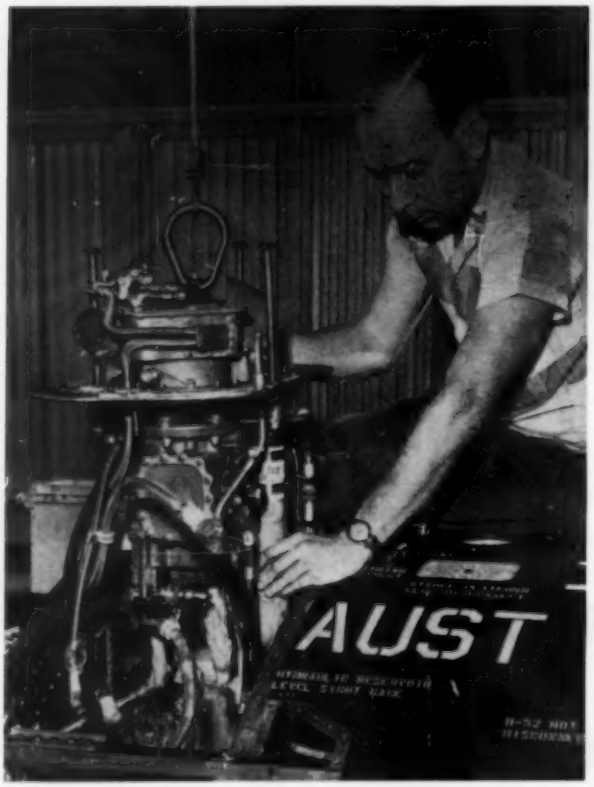


FIG. 1. X-15 APU'S are typical of present hardware. Two, 40-hp units each provide 16 gpm at 3000 psi, and 4 kva of 400-cps a-c. Life is about 150 hours under conditions ranging from sea level to almost outer space.

Thermoelectric and thermionic systems convert heat directly to electricity. They have no moving parts and impart no gyroscopic action to the vehicle. For space flight, they would require no stored fuel. Solar or nuclear radiation could provide the energy. Because of their low efficiency of about 10%, many converters would be needed.

Fuel cells have emerged from the laboratory, and space flight tests are scheduled for late summer, 1962. These systems convert chemical energy directly to electricity. Prototype hardware is operating today outside the laboratory with thermal efficiencies of 60% or more. The best, closed cycle, turbine systems for aerospace vehicles operate at less than 25% thermal efficiency, and improvements will be difficult to achieve.

These developments are needed to meet requirements of future accessory power systems:

New fuels that can pack more energy into limited tank space. Cryogenic hydrogen and oxygen will

units — present and future

Accessory Turbine Dept., General Electric Co., West Lynn, Mass.

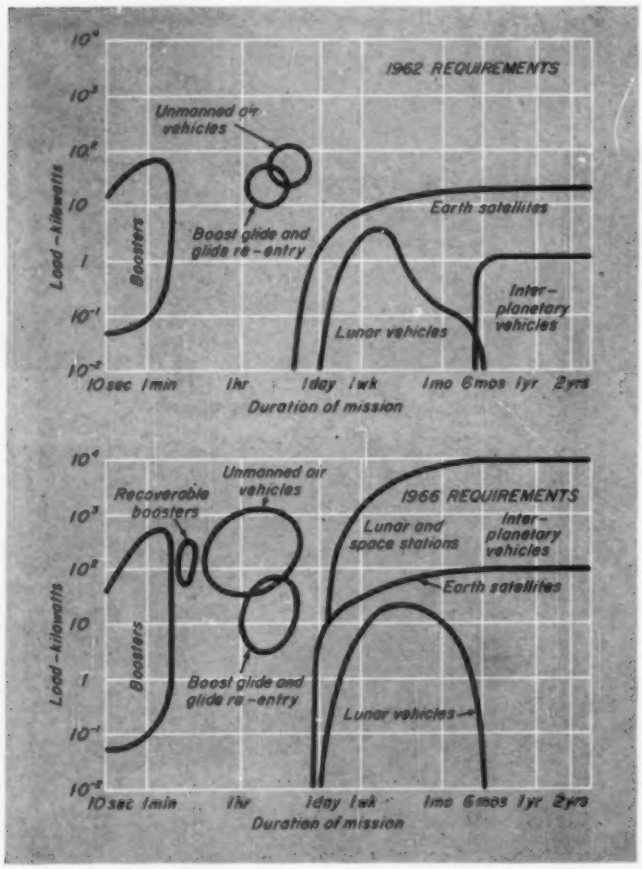


FIG. 2. FORECAST OF POWER REQUIREMENTS FOR APU'S.

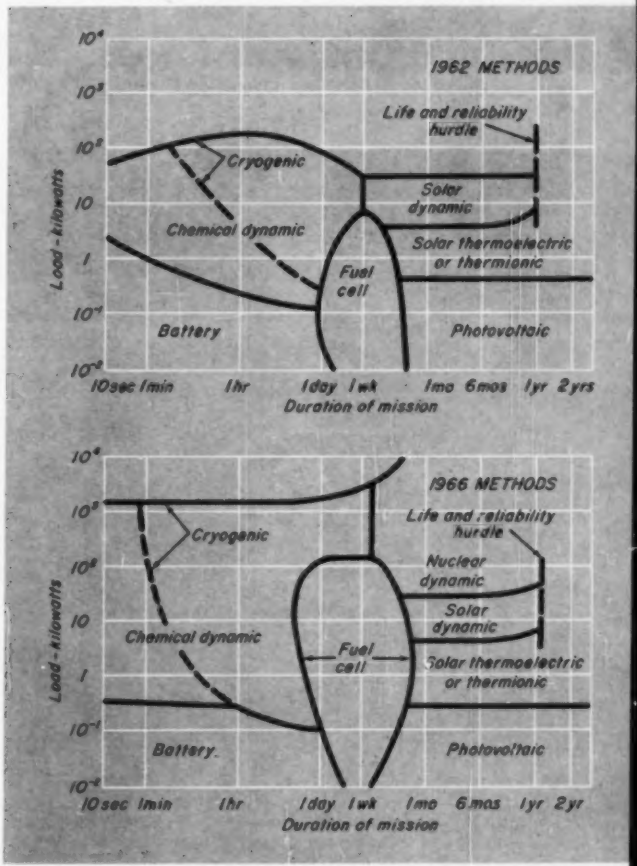


FIG. 3. FORECAST OF ENERGY CONVERSION METHODS.

be tried. Gas temperatures will be increased for higher efficiencies.

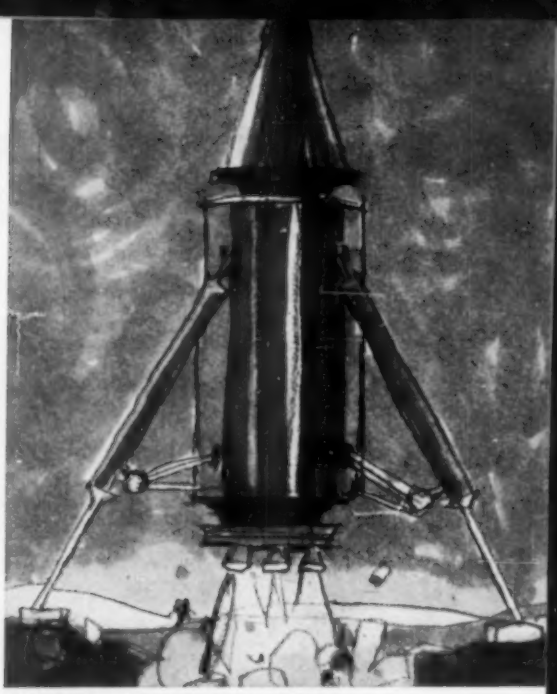
New materials that will withstand higher temperatures. Experiments are underway with turbines of pyrolitic graphite for temperatures to 5000 F, which would melt today's metal turbines.

Weight reduction by changes in turbine design. Long life turbines of conventional design have been fabricated from sheet metal. Extremely small turbines have been designed to operate at speeds over 250,000 rpm.

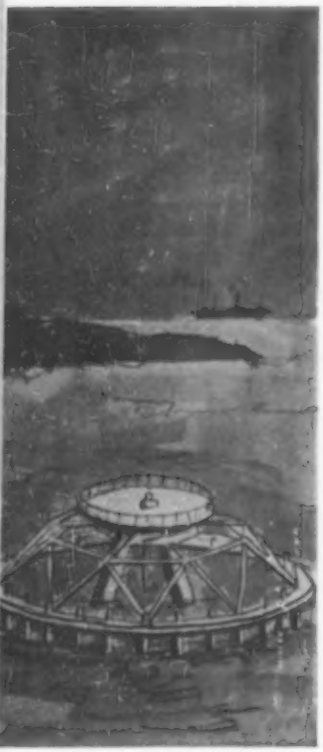
New energy sources for deep-space missions. APU efficiency must be increased tremendously, and the weight and volume of chemical tankage must be reduced. Systems being seriously considered are solar and nuclear turbogenerators in which heat derived from the sun or a reactor is used to drive a working fluid through a turbine. The working fluid would be a liquid metal such as mercury, sodium, or potassium, rather than a gas. Problems include sealing the corrosive working fluid, and heat rejection which would require huge radiators. These radiators would be subject to damage by meteorites.

• **Future Design Philosophy**—The trend, as shown in Figure 3 from the same source as Figure 2, seems to be toward some sort of direct conversion of energy to electricity, which will provide all the power for the vehicle—including fluid power. Thus, motor-pumps will supply hydraulic power taking electrical power from the system as needed. To reduce hydraulic pump weight, the trend is to high speed operation at 40,000 rpm or more. Also, variable delivery will be required to improve system efficiency by reducing the drain on the power source during partial loads. Variable delivery pumps are being developed to replace fixed delivery pumps of the same capacity, without increasing size or weight.

Advanced hydrofoil designs make use of Bendix hydraulic actuators.

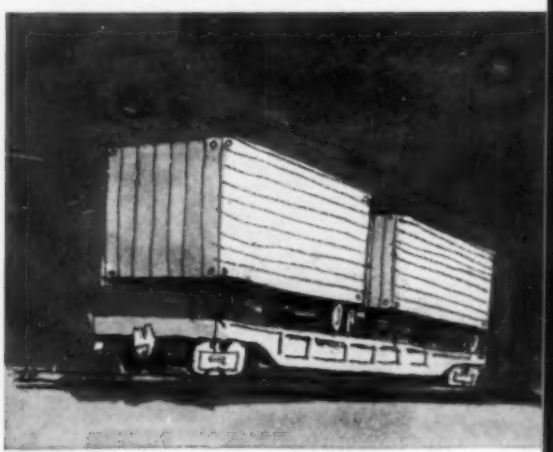


Telescoping shock absorber systems are being designed for lunar landings.



Deep water loading stations employ shock absorbers.

Raising, lowering and positioning missiles with the aid of Bendix hydraulic actuators.



Bendix shock absorbers cut damage claims on railway shipments.

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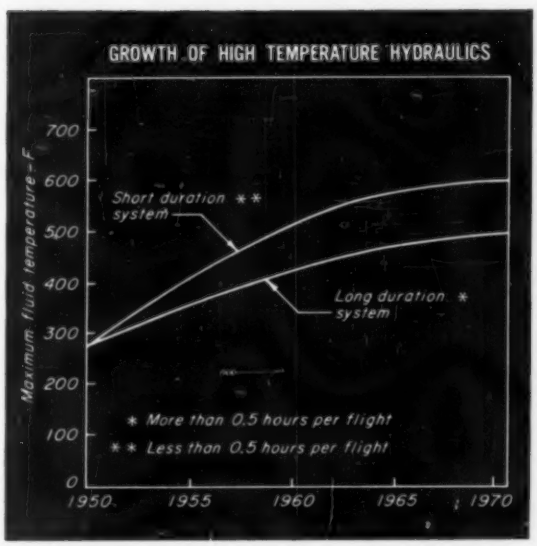
THE Bendix CORPORATION

. . . reliability at high temperature

• By **WILLIAM G. NELSON,**
Group Engineer, The Boeing Company, Aero-Space Division, Seattle, Wash.

WILLIAM NELSON started with Boeing in 1946 as liaison and design engineer on air refueling systems, bomber modification programs, and tanker hydraulic systems. His present responsibility is engineering supervision of accessory power system staff work for existing missiles. Nelson is active in SAE aerospace functions, and is a representative on the BuWeps Industry Material Reliability Advisory Board, hydraulics and pneumatics subcommittee.



The push to higher temperature hydraulic systems results from ever increasing flight speeds, and demands for reduced system weight. Will these factors force designers to higher and higher temperature systems? Or, will state-of-the-art fluid temperatures level off resulting in more work being applied to improving reliability?

Because reliability has a major effect on the trend to higher temperatures, I consider it the foremost problem. Although hydraulics has earned a respectable reliability position in missiles, its reputation in long flight duration, manned vehicle applications, by far the most important, is not satisfactory. To make matters worse, long duration systems have the greatest need for high temperature hydraulics. In these applications reliability will dictate system temperature, and weight, penalties will become secondary. This in itself will cause a leveling-off of the trend to higher temperatures. Reliability will catch up in this period by having top design consideration.

The following suggestions provide something concrete in this frequently discussed area.

• Reliability is designed *into* an item. Therefore, spend more time analyzing the original design rather than trying to test reliability into it later.

• Put teeth into design reviews. Companies generally have a number of expert engineers for each product line. Give them time to team up and review the designs of each other's components. Do this before designs are frozen.

• Use more development testing during the design phase. Have the designer get better acquainted with actual test work.

• Use all test information which reveals how overall system reliability can be improved.

• Never substitute known component reliability for cost savings of an alternate component.

• **Seals**—A major problem with high temperature hydraulic systems, as with all hydraulic systems, is seal reliability. Neoprene WRT, Viton, and silicone seals with single turn Teflon, and glass-loaded Teflon backup rings are advances in elastomeric seals.

RELIABILITY AT HIGH TEMPERATURE

Some progress has been made in metallic seals as described by Raymond.[1] However, when one considers the tremendous difficulties in developing the present MIL standard sealing concepts, which are yet quite marginal in certain applications, he gains an understanding of the much more difficult task of sealing high temperatures. Most past efforts provided an empirical solution of some particular sealing problem. Very little effort is made to analyze just how marginal some seals are. Government contracts for establishing seal installation standards for high temperature systems may be the only solution.

- **Pumps**—The two most critical pump problems are piston slipper failure and variable pump compensator oscillation. Slipper failures apparently are independent of pump design, because the problem has been noted as the main temperature-limiting factor (at about 550 F) on three different designs. Because of changes in damping, spring and orifice characteristics at higher fluid temperatures, pump internal servo systems which provide variable delivery flow are still plagued with compensator instability. Improvements in pump compensator stability are slow, as applications are few.
- **Valves**—Next to pumps, the pacing component in high temperature hydraulics is the modulating valve. It also has some instability problems. Most advanced systems require power amplification by electrohydraulic servovalves. At present, null shift, valve instability, and torque motor coil problems tend to peg the temperature limit of servovalves at 450 F to 500 F.
- **Fluids**—Five years ago fluids seemed to be causing the big delay, but recent developments in synthetic fluids and high temperature mineral oils appear to have brought this item more in line. Polyphenyl ethers and mineral oils have made the most significant advances.[2]
- **Maintenance**—A significant problem not often mentioned is *mantainability*. Because of design aimed at improving reliability, the maintenance of high temperature systems has become critical in the following areas:

  Brazed Tubing Connections: It should be possible to isolate a section to be repaired instead of draining the entire system.

  Metal Seals: Some method of take-up of actuator rod gland seals (with some types) and care of the seals and sealing surfaces is needed.

  Synthetic Fluids: Recovering used fluid because of their high original cost, and the storage problem associated with some fluids because of their hydrolytic stability are design considerations.

The table shows several vehicles with their planned, maximum fluid operating temperature compared to the operating temperature that would result with lowest system weight.

Future space applications generally do not involve high temperature hydraulics unless re-entry is involved. Because man is involved in most future applications, the trade between reliability and weight will decide operating temperature with reliability winning in every case. Improvements in the reliability of existing Type II (—65 F to 275 F) and III (—65 F to 400 F) system hardware will be made instead of increasing operating temperature. Figure 1 summarizes the future of high temperature hydraulics by predicting the leveling trend.

Competitors to hydraulics, mainly hot gas systems, also tend to reduce the need for higher temperature hydraulics. However, these competitors have the same major problem of finding applications, with even a greater requirement to demonstrate reliability.

---

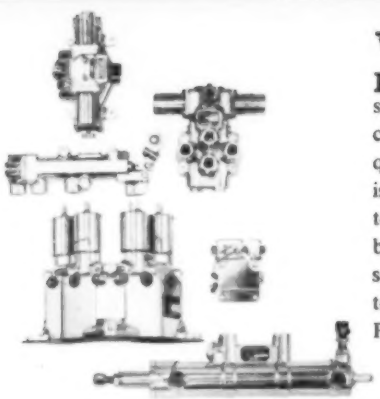
(1) "High Temperature Hydraulic Seal Developments for Future Flight Vehicles," by E. T. Raymond, 1960.
(2) "Development Aspects of High-Temperature Hydraulic Systems," by W. E. Mayhew.

HIGH TEMPERATURE HYDRAULIC SYSTEM STATUS

Vehicle	Length of System Operation	Development status	Maximum fluid operating temp.	Max. fluid operating temp. for min. system weight
B-58	Long*	Operational	350 F	450-500 F
B-70	Long	Development	450 F	600-700 F
DS-1	Long	Development	400 F	700-1000 F
Supersonic transport	Long	Research	400 F	500-600 F
IM-99B	Short**	Operational	400 F	400 F
X-15	Short	Operational	400 F	

* More than 0.5 hours per flight. ** Less than 0.5 hours per flight.

Circle 3 ➔



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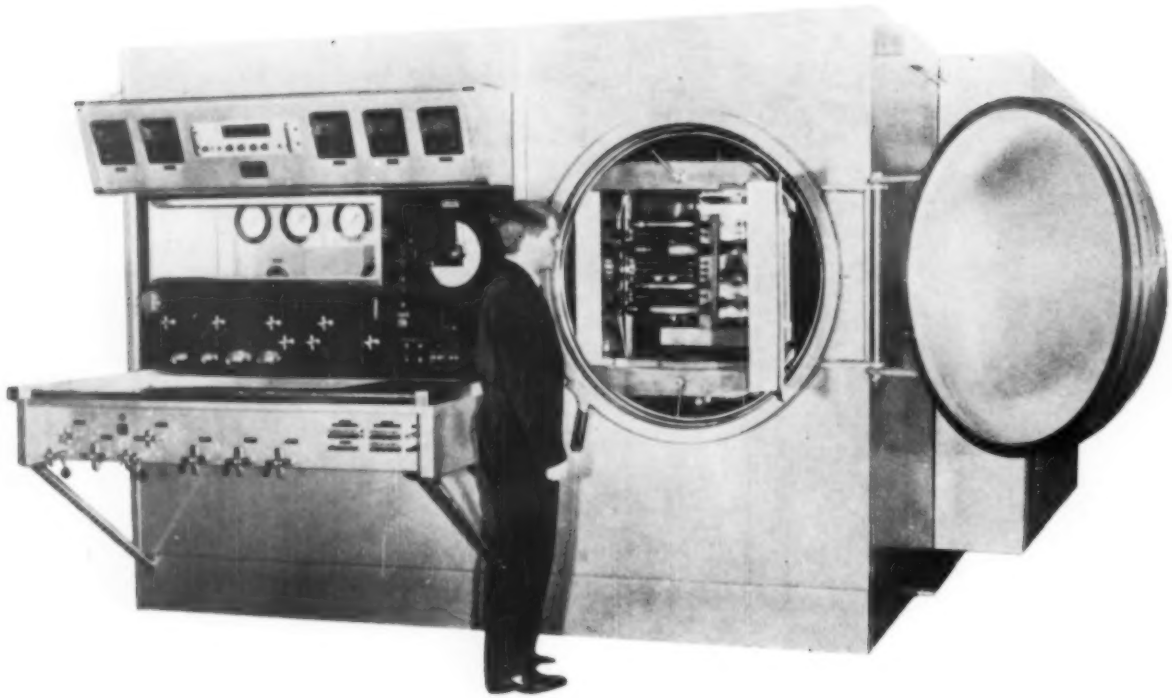

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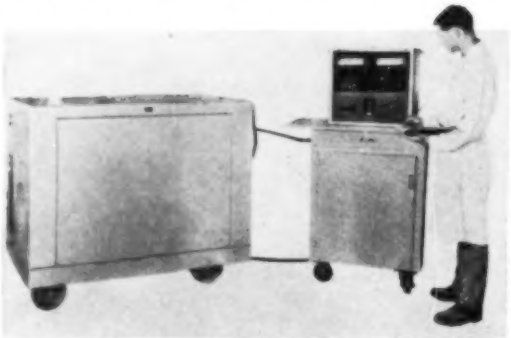

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. . . fluids and seals for high temperatures

• By **WILLIAM E. MAYHEW,**
Fluid Systems Laboratory,
Republic Aviation Corporation,
Farmingdale, L. I., N. Y.

WILLIAM E. MAYHEW *has been project engineer and hydraulic system group leader on Air Force contracts for high temperature hydraulic systems. He is in charge of all research and development on hydraulic and pneumatic systems and director of Republic's new fluid systems laboratory.*

For hydraulic systems in aerospace vehicles we need fluids to withstand extremely high temperatures and nuclear radiation. At present, no organic fluids appear capable of withstanding temperatures above 1000 F for extended time periods. Liquid metals and salts with high melting points are the only fluids which can be used at 1000 to 2000 F.

Glass mixtures, melting as low as room temperature, are another possibility as power transmission media. They provide good lubrication and are extremely stable. However, they are volatile at high temperatures. These glass mixtures should be investigated. The right mixture might make a good, high temperature fluid.

Republic Aviation's work in developing a fluid power system using a polyphenyl ether fluid shows that this also has considerable promise for high temperature and nuclear radiation environment.

Pneumatic or hot gas servo systems have no need for a liquid to withstand high temperatures or nuclear radiation. Although other design problems are introduced, pneumatics is a possible solution for operating short duration aerodynamic, attitude, and vector controls in a high temperature or nuclear environment.

• **Metallic Seals**—Higher temperatures combined with pressures, from vacuum to 5000 psi, require new seal materials. Organic materials used in the past won't hold up under severe temperatures and pressures. Metallic seals are needed. Seal and component designers must also cope with material growth and dimensional stability as well as absorption and transmission of radiated particles through the system.

• **Reliability**—Development, evaluation, and testing of components and complete systems under expected environments must be done at the time of preliminary design. This will be costly, but necessary for high reliability in future aerospace vehicles.

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NEW PRODUCTS

NEW "HDP" HOSE ASSEMBLIES BY ANCHOR FOR HIGH PRESSURE COMPRESSED GAS SERVICE

A completely new type of hose assembly has been developed by Anchor Coupling Co. Inc. specifically for aircraft and missile high pressure compressed gas ground servicing. These new assemblies have an inner tube of "HDP" (a specially compounded high density polyethylene material) resistant to the effusion of high pressure gases and inherently smooth and clean. The "HDP" inner tube is reinforced with stainless steel wire braids and spiral plies. The reinforcement is protected with a tough perforated neoprene cover resistant to abrasion and exposure. This new type hose assembly is now covered by Military Specification MIL-H-26666A and is recommended for high pressure pneumatic ground servicing in the temperature range of −65°F to +160°F with compressed air, nitrogen, helium or other inert gases. Working pressure for the -4, -6, -8, and -12 size is 4000 psi and a -6 size is available for 6000 psi. Assemblies are available in continuous lengths up to 50 feet with stainless steel couplings and 37° flare swivel female ends to mate with male end fittings conforming to MS33656. The assemblies are furnished to the cleanliness requirements of the Mil-Spec. or to the customers' individual requirements. "HDP" hose assemblies to the requirements of MIL-H-27462 for 8500 psi working pressure are under development and will be available soon. "HDP" assemblies were developed by and are available from Anchor Coupling Co. Inc., 338 North Fourth Street, Libertyville, Illinois.

Circle **8** on Reader Service Card

...progress of ground handling equipment

• By **WALTER A. ROMAN**
Engineering Supervision, Hydromechanical Section, American Machine & Foundry Co., Greenwich, Conn.

WALTER ROMAN was project engineer with AMF in charge of design and development of the launcher and ground support equipment for the BOMARC missile. He also supervised the design of ground handling equipment for the Bull Goose missile and the hard site elevating and support system for the BTL antenna on Titan Mr. Roman is presently overall coordinator of the Titan Mechanical Simulator Test Program providing engineering data on the hard based Titan drive system.

In the last ten years there have been many changes in the method of handling and servicing missiles. The two major reasons are increased size, and complexity of the missiles themselves.

As missiles became larger, increased use of hydraulic power for handling and launching was quite natural. Control valves, pumps, motors, and cylinders were available as commercial items. Accumulators could store power for release at a moment's notice. There were no serious problems in hydraulics or pneumatics which could not be overcome by slight modification of existing equipment.

The next big steps in missile development were the ICBM's and later the space vehicular systems. Handling and support of these systems were a formidable task and called for ingenuity in design.

For example, one hard base launcher system, designed and developed by AMF, uses 350 gpm at 3000 psi to open the massive silo doors and elevate the missile to the surface. The hydraulic equipment to generate and control this power in many cases was not available. Paralleling of components such as pumps, filters, and hoses proved most reliable. In most cases, vendors redesigned standard equipment to meet the new requirements. Other equipment was newly designed. Every piece of equipment went through an exhaustive test program before it could qualify.

• **Increased Testing**—Five years ago, expenditures for missile ground support equipment accounted for 25 to 30% of the total system cost. For ICBM's and space missiles, it now amounts to 60 to 70%. The military is becoming increasingly aware that ground support equipment is not merely an assembly of commercial components, but must be designed specifically for the performance intended. The equipment must be reliable, fail-safe, simple, and high performance. A larger budget allotment is going for qualification testing, quality assurance testing, development testing, static testing, and better countdown and checkout procedures.

• **Space Systems**—The space age has brought with it the need for larger handling, servicing, and support equipment. Handling and servicing equipment for such large missiles as Saturn has already been developed during the past year. New transportation methods use huge trailers over land, and barges over waterways.

A new area created by the space program is space support equipment. Designers of this equipment deal with environments which do not exist on earth, such as near perfect vacuum, extreme heat and cold, zero gravity, high radiation, meteoric bombardment.

Space equipment must be small and light. Power to operate this equipment must be adequate for construction, mining, and mobility. Hydraulic systems may be too heavy. Pneumatics seems like the probable choice. Look to cryogenics for some good solutions. Perhaps the potential energy in liquid nitrogen can be used as a power source.

Some problems which must be solved by hydraulic engineers and designers to achieve reliable operation of space equipment are: better tubing joints to minimize leakage, fluids and seals which remain stable under exposure to radiation and extreme temperature changes, vaporization of liquid lubrication necessiting self-lubricating solid and solid film bearing surfaces.

Hydraulics and pneumatics in GSE, have they kept pace with missile and space system development? I say yes,—but it could be much better. Up to now, they have held their own, but greater emphasis must be placed on this type of development activity. Whether large scale, high pressure components for supporting missiles on the ground, or new, lightweight, high powered units for extra-terrestrial environments, we should be planning the development of hardware with a high level of operational reliability now to insure its availability when the need arises.

PAUL DECKER *was the unit engineer at IIT Federal Laboratories for the design of the Bomarc propulsion system test set and the Bomarc mechanical calibration test set. Also, he helped design the Bomarc missile exerciser. He is a member of the American Society of Mechanical Engineers.*

. . . hydraulic and pneumatic checkout needs

• By PAUL R. DECKER,

Unit Engineer, Mechanical Design & Development, ITT Federal Laboratories, Fort Wayne, Ind.

The design of hydraulic and pneumatic missile checkout equipment is unique in that brute force is usually not a requirement, but the equipment must be more accurate and reliable than the component or system which it checks. Therefore, the performance specifications of missile systems and subsystems become the specifications of the checkout equipment, but with a higher order of accuracy and reliability tacked on.

• **Pneumatic Sequential Tests**—Present pneumatic checkout equipment is of the red-and-green light, go-no-go variety, where as many as 150 tests and evaluations are performed automatically merely by pushing one button. These sequential tests are controlled either by automatic stepping switch circuits or by tape programmer circuits. All test set hook-ups are made directly to the missile. The tests can be run from start to finish without operator observation if all tests are *go*. If the test set encounters a malfunction in a missile system or component, it will not advance beyond the malfunction and will isolate and indicate the faulty component by digital or display readout.

• **Hydraulic Tests**—Present hydraulic checkout equipment tends to be semi-automatic, since many of the more critical missile hydraulic assemblies are removed from the missile for bench type tests. With this type of test the operator requires greater ability, since he—rather than the test equipment—determines whether the part is faulty. The operator makes this determination by evaluating pressure and flow gauge readings.

• **Design Limited By Components**—As missiles and spacecraft become more complex, the need for greater reliability and accuracy increases. Checkout equipment must follow suit, using off-the-shelf components. Today's tight delivery schedules allow the equipment designer very little time to design specialized components and experiment with new and untried concepts. He must design circuits, using the most advanced application techniques, knowing full well that he is limited by existing vendor components. This throws most of the burden of basic research and development on component manufacturers. At the present time, few component manufacturers seem to be doing much more than improving this year's models to take care of next year's problems.

• **Pneumatic Equipment Needs**—It would be desirable to have highly accurate regulators, gauge savers, and pressure switches which maintain consistent tolerances and settings. They should not drift during several months operation, though exposed to temperature and humidity changes. They should be easier to adjust. At present for example, to calibrate a pressure switch for 1500 ± 15 psi, the operator must overshoot the setting, then undershoot it, and jockey back and forth until the setting falls within the required tolerance. This takes a lot of patience.

• **Hydraulic Equipment Needs**—Equipment size and weight is the most outstanding problem. Smaller, more efficient heat exchangers would be welcome for high flow capacity systems. Increasing flow rate through hydraulic filters would eliminate the need for parallel circuits. Another problem is the noise level generated by present motor-pump units working at 75% to 90% capacity. This is both a human engineering and a functional problem. A constant noise of high pitch and db level can contribute more to operator fatigue than the work he performs.

• **Modular Components**—The concept of connecting individual components together is rapidly becoming obsolete. A leak of 1 oz/year of gas can cause excessive error in checkout readings, particularly with go-no-go equipment. Therefore, it seems necessary to develop a *universal* component. Functions such as regulating, valving, monitoring, venting, and positioning could be performed by adding a particular section for each function. The result would be a complete, one-piece, stacked circuit, eliminating a maze of tubing and many troublesome fittings. For some missile checkout equipment, this type of assembly should have the accuracy of a laboratory instrument and the ruggedness of an industrial component, yet be light and small.

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- Allows zero-backlash probe attachment.
- Electrical windings isolated from hydraulic fluid without the use of seals.
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Circle **75** on Reader Service Card

Aerospace Report

...environmental

• By **HOWARD C. ZINTZ**, *Director of Engineering,*

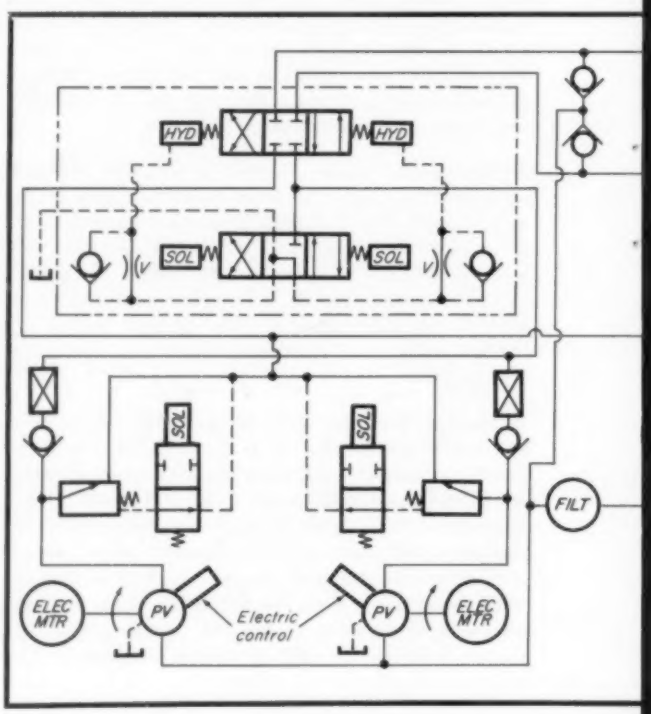
INABILITY of unmanned missiles to compensate for operational failures in flight, has increased emphasis on reliability during the past five or six years.

The shake table, the rocket sled, and the humidity chamber performed their tasks well enough for aircraft components. However, missile components failed in service after successfully passing individual environmental tests such as acceleration, and vibration. It was evident that combined environmental testing was needed.

Acceleration is one of the requirements in most combined tests. For this reason, the environmental test chamber must be mounted on a centrifuge to accelerate the test specimen while it is exposed to the required environments.

Designers found that hydraulic power and control were well suited for centrifuge operation. Some of the advantages of hydraulics are:

- Infinitely variable speed adjustment.
- Hydraulic drive motors may be used in parallel without equalizing electrical circuits. Also multiple power ranges are available on the same installation.



testing

The Rucker Co., Oakland, Calif.

During his eight years with The Rucker Co., HOWARD ZINTZ *has served as chief engineer and currently as director of engineering. He lectures on industrial hydraulics at the University of California Extension Division, and is a registered professional engineer in New York and California.*

- Torque can be closely controlled for automatic test programming.
- Braking characteristics during deceleration are excellent.
- Even if power fails compietely, the centrifuge can be hydrauically decelerated.
- Frequent stops, restarts, and acceleration of heavy loads won't cause overheating.
- Hydraulic drives are economical to build and easy to maintain.

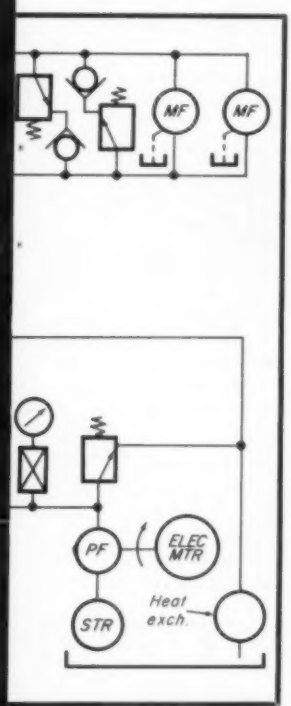
As missile reliability engineers asked for combined environmental test equipment, new environments were added to centrifuges. Counter-rotation was added in 1956. The following year, temperature environmental control of a test object was included. Two years later vibration testing was added.

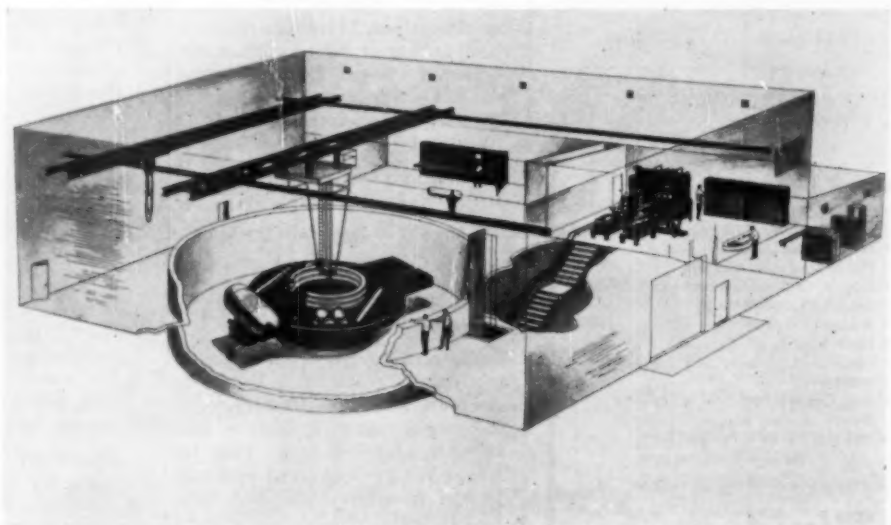
• **Fluid Motors Drive Turntable**—The hydraulic system illustrated powers a centrifuge designed and built by Rucker for the Naval Missile Center, Pt. Mugu, California. It is a disc type centrifuge, 32-feet in diameter, to test loads up to 5000 lb at accelerations to 100 g.

The hydraulic motor drive for the 30,000-lb rotor gives full acceleration force at 140 rpm, although speed may be reduced to 10 rpm. The drive motor is rated at 250 horsepower. Hydraulic and pneumatic power is transmitted to the disc by a six-pass rotary joint on the centrifuge spindle.

Special components for the drive system include remote control output adjustment for the hydraulic pumps, a meter for speed measurement down to .01 rpm, and a remote volume indicator for the pumps. All equipment for stopping, starting, adjusting, and reading speed is located at a remote console.

• **Larger Centrifuges**—On Rucker drawing boards today is a centrifuge with a 15,000-hp hydraulic drive, accelerating from 0 to 100 g in five seconds. Its 50-foot radius disc includes temperature, altitude, humidity, and vibration control, and rotation of the specimen about two axes simultaneously. This machine will test a 10,000-lb. object such as a medium sized missile or an entire large rocket engine.



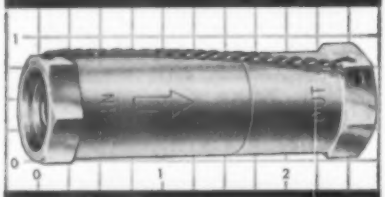


REMOTELY OPERATED CENTRIFUGE will test 30,000-lb loads at accelerations to 30 g's. Tests are observed through a closed-circuit television system. Located at Edwards Air Force Base, it is the free world's largest combined environmental test facility.

BOOSTER PUMP supplies oil to the two main variable displacement pumps. It also furnishes oil to the fluid motors to prevent cavitation while they are running free.

Another FLUID REGULATORS Product

NEW RELIEF VALVE

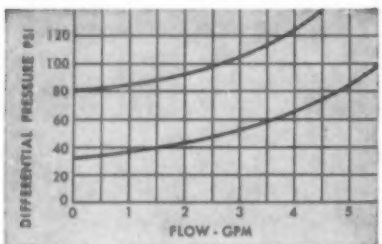


- Fast Response
- Accurate Repeatability
- Long Life
- Light Weight

• Used in the directional control system of a missile, this small light weight valve was designed, manufactured, tested and delivered in just four weeks.

It can be custom built in a wide range of sizes and design variations to meet users specific size, weight and performance requirements.

Its another example of Fluid Regulators' ability to meet customers exacting specifications—from problem analysis thru delivery.



SPECIFICATIONS

- Cracking Pressure: 20 to 100 psi
- Proof Pressure: 3000 psi
- Temperature: −65°F to + 275°F
- Fluids: Hydraulic and fuel
- Internal Leakage less than MIL-V-5527A
- External Leakage: Zero
- Weight: 1.6 oz.
- Ports: AND 10050-6
- Material: Aluminum body, S.S. ball and spring
- Seat Construction: Soft or Stainless Steel
- Part No. 7512R — For Soft seat
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Circle **44** on Reader Service Card

AEROSPACE COMPONENT DATA

Sealed Solenoid Hydraulic Valve

Features: Direct-operated, 3-way, 2-position solenoid valve is designed primarily for MIL-H-5606A oil at operating pressures to 3000 psi throughout the temperature range of −65 F to 275 F. The

continuous duty solenoid conforms to MIL-S-4040C and is completely sealed. Operates on 18 to 30 vdc. Maximum current drain at 30 vdc and 70 F is 1 amp. Maximum response time is 0.06 sec.

Specifications: Maximum pressure drop at 5-gpm flow in either direction is 440 psi. Dimensions are about 4 x 3 x 2 in. Weight is 1.5 lb. Ports are according to AND 10050-6 for ⅜ in. tube.

Designation: MC-4565-1.—*M. C. Mfg. Co., Lake Orion, Mich.*

Circle **500** on Reader Service Card

Cold Gas Attitude Control Valve

Features: Extremely high response, miniature attitude control valve is designed for cold gas attitude or directional control systems in missiles or space vehicles. Fast response results from an exceptionally low impedance solenoid combined with a bi-stable poppet which uses full flow forces for fast actuation. Also the solenoid, valve, and nozzles are integrated in one, close-coupled package which reduces response delay. The basic design concepts lend themselves to variations to meet specific circuit requirements, and changes in nozzle design can be made for variations in thrust requirements.—*James, Pond & Clark, Inc., Pasadena, Calif.*

Circle **501** on Reader Service Card

Control, Monitoring, & Testing Systems

Brochure shows recently developed equipment to simulate, control, or monitor transient, static, or dynamic conditions. Allows observation of the performance characteristics of a product. A self-contained, portable hydraulic power cart is shown for testing hydraulic components.—*Meriam Instrument Co., Special Equipment Div., Cleveland.*

Circle **502** on Reader Service Card

Sealed Plunger Limit Switch

Features: Hermetically sealed plunger, aircraft limit switch has corrosion resistant materials throughout and potted leads. For

external mounting and exposure to ice, water, and mud. Is qualified to MIL-S-6743, and meets icing operation requirements.

Specifications: SPDT. Operating force, 6.7 lb ±2.2 lb. Release force, 3.5 lb., min. Pretravel, 3/16″. Overtravel, 0.250″ min. Weight, 0.125 lb. Rating is 5 amp resistive and 3 amp inductive at 28 vdc. Size, 2″ x ⅝″ x ⅝″.

Designation: 61574 series.—*Haydon Switch, Inc., Waterbury, Conn.*

Circle **503** on Reader Service Card

diversity

A business school prof might call it product diversification to broaden the marketing base, but it all boils down to the basic American drive for a better standard of living. But, all is not so crass! This base broadening business brings *you* the products you need to set your own standards. And since most of our products were designed to meet specific customer demand, we've had a hand jacking up quite a few standards. Before we get too philosophical, let's look at the many things Hoke makes:

1 FORGED NEEDLE VALVES 300 Series:
3000 psi
Brass, 303 SS, 316 SS, Monel
Aluminum ⅛" to ⅜" NPT and with integral tube fittings

2 BAR STOCK NEEDLE VALVES 270 Series:
3000 to 5000 psi
Brass, 430F SS, 316 SS, carbon steel, carbon steel and SS
⅛" to ½" NPT and with integral tube ends

3 PRESSURE REGULATORS 680 Series (gen'l purpose):
Max. delivery press. 140 psig
Max. inlet press. 2500 psig
¼" NPT male needle valve outlet Std. CGA inlet

4 CHECK VALVES 570 and 580 Series:
2000, 3000, 5000 and 6000 psi
Brass, 303 SS
⅛" to ½" NPT and with integral tube fittings.
Ball and piston types

5 SOLENOID VALVES Series 90 (2-way type): Series 95 (3-way type):
Differential press. ratings to 2000 psi
Brass, 303 SS
⅛" and ¼" NPT or JIC tube connections
Choice of coils, housings, corrosion-resistant trim

6 BAR STOCK NEEDLE VALVES 280 Series (metering):
3000 psi
Brass, 316 SS
⅛" and ¼" NPT
1/16" and ⅛" orifice

7 PACKLESS VALVES 473 Series (bellows seal):
400 and 2000 psi
316 SS
½" NPT

8 PRESSURE REGULATORS 920 Series (ballast operated):
Max. del. press. 4500 psig
Max. inlet press. 5000 psig
¼" NPT inlet and outlet

9 FORGED NEEDLE VALVES 100 Series
10,000 psi (WOG)
Weldable forged carbon steel
⅛" to ½" NPT

10 SAMPLING CYLINDERS
Service press. 400 and 1800 psi
304 SS
⅛" to ½" NPT outlet
Single or double valve types
Sizes 10 ml. to 1 gallon

11 TOGGLE VALVES 490 Series (cam-closing):
1000 and 2000 psi
Brass, 303 SS
⅛" to ½" NPT

12 TOGGLE VALVES 450 Series (spring-closing):
200 psi
Brass, 303 SS
⅛" to ⅜" NPT and with integral tube fittings

13 PRESSURE SWITCHES PSG-375 Series:
Operating range 15 psig to 500 psig (max. setting)
Aluminum and SS housing
Proof Press.— 150% max. operating pressure
Burst Press.— 250% max. operating pressure
⅛" NPT port or AND 10056-4, 37½° flare

14 PACKLESS VALVES A431 Series (brass bellows seal):
400 psi
Brass
⅛" and ¼" NPT

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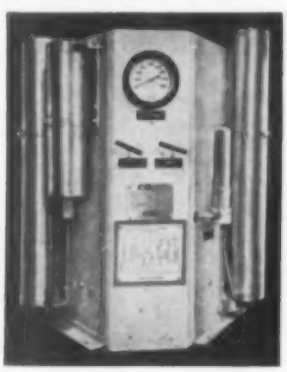

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AEROSPACE COMPONENT DATA

Metallic Static Seal

Features: Metallic, static V-seal is reinforced to produce increased strength and zero leakage, while maintaining low compressive force. The resulting lower flange loading often produces size and weight reductions. The same surface finish as for elastomer seals (32 rms or finer) is recommended.

Specifications: For pressures from vacuum to over 30,000 psi and temperatures from −320 F to 2200 F. Manufactured from high strength, corrosion, and heat resistant materials, with various coatings and platings. Seals are available for all standard AN cavities, and can be supplied in irregular shapes and sizes.

Designation: Apex.—*Servotronics, Inc., Buffalo, N. Y.*

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Miniature Shut-Off Valve

Features: Stainless steel, miniature shut-off valve has positive bonnet lock for safety. For use with gases, air, hydraulic oils, and chemicals. Typical applications are gas sampling cylinders, pressure gages, and high pressure instrument sampling lines.

Specifications: Operating temperature, −65 F to 250 F. Pressures from high vacuum to 3500 psi. Shut-off torque at 2000 psi is 6 in.-lb. Size, ¾" wide x 1⅝" long x 2" high, opened. Weight, 5 oz. Two ¼" male pipe ports.

Designation: SSG106-2L.—*Robbins Aviation, Inc., Los Angeles.* ▼▼▼

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Very low back pressure. Disc sealing on "O" ring seat—3,000 PSI service. 1 PSI crack pressure. Leakproof.

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Disc sealing on "O" ring seat. Excellent flow. —2 PSI crack. ¼, ⅜, ½ MPT. Leakproof.

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Disc type—"O" ring sealing. 2 - 6 PSI crack pressure. ¼, ⅜, ½ MPT. Also —4, —6, —8 AND10050. High pressure — leakproof.

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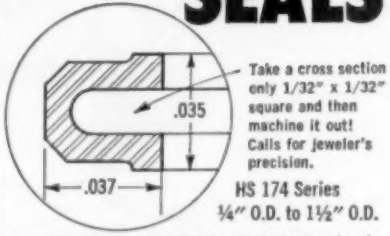

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HS 174 Series
¼" O.D. to 1½" O.D.

Normally made from 17-4PH bar stock, hardened and silver plated as standard. Available in other materials and plating. For temperature extremes of −450°F to 2000°F in exotic liquids and gases. For use in valves and actuators where space is at a premium. Seals with only light flange loading. Accommodates flange breathing due to thermal or pressure stresses. Send for catalog of Metal and Cryogenic Seals.

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DENISON hydraulic power
controls giant **JPL** antenna
for missile and satellite...

TRACKING

110-FOOT HIGH RECEIVING ANTENNA *at Goldstone Tracking Station, California tracks and communicates with spacecraft in U. S. space exploration program. Denison Series 600 variable volume axial piston pumps (right) supply hydraulic power to main drive system.*

TRACKING and communicating with space vehicles is the vital mission of this 85-foot diameter receiving antenna now in operation at the Goldstone Tracking Station. The big dish, operated by the California Institute of Technology Jet Propulsion Laboratory for the National Aeronautics and Space Administration, is driven and held "on target" by dependable Denison hydraulic power.

To aim the 30-ton parabola, acquire and accurately track objects thousands of miles deep in outer space calls for fast, smooth action and precision control. That's why Goldstone's engineers chose hydraulics—*and Denison hydraulic equipment*—to handle the job. Each Denison component in this installation—pumps, motors, valves, controls—incorporates instantaneous response . . . simplicity . . . reliability . . . trouble-free service . . . *all essentials for dependable Ground Support Equipment.*

In all phases of Ground Support Equipment—missile transporting, checkout, erecting, launching, tracking—Denison has *proven capability.* Ask your nearby Denison Hydraulic Specialist to show you how Denison equipment (with capacities from 3 to 120 gpm and pressures to 5000 psi) can meet the particular requirements of your GSE systems.

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SEALS

Are No. 1 in Any Engineer's Book

Sealing problems multiply for missile men as they probe further into the realm of extreme pressures and temperatures encountered at aero-space frontiers. By solving these critical problems in missile, aircraft, and nuclear applications, Hydrodyne is helping to write new chapters in the annals of advancing technology. Skinner High Temperature Seals produced by Hydrodyne answer the need for a seal that functions reliably in temperature extremes from —420° to +2000°F. Precision-machined from nickel alloys and other temperature-resistant materials, these seals are designed for best distribution of stresses in a given application and environment.

- For fuel pumps, compressor units, turbine starters
- With reactive or contaminating fluids and gases
- In missiles and high performance aircraft

*some footnotes

MACHINED BELLOWS

Proven precision machining process (weld-free) assures absolute structural integrity, eliminates failures from metal fatigue through as many as 1,000,000 cycles. Controlled-wall-thickness technique concentrates strength at stress points. Machined bellows are custom designed in lightweight alloys and materials resistant to environmental extremes.

ROTARY FACE SEAL

All-metal bellows of steel or nickel alloys; sealing faces and mating rings of carbons, alloys, ceramics, other materials for specific environments: Temperatures, —400° to +1200° F; pressures, 0 to 10,000 psi; speeds to 60,000 rpm.

HYDRODYNE CORPORATION

Subsidiary of Donaldson Company, Inc.
7350 Coldwater Canyon Avenue,
North Hollywood, California

Circle **61** on Reader Service Card

AEROSPACE NEWS

from the fluid power field

Kidde elects president and vice president

Robert L. Dickson has been elected president of Walter Kidde & Co., Inc. Dickson joined the company in 1941, and has been executive vice president for the past 2½ years. Edward C. Leeson has been named vice president and manager of Kidde's Aero-Space Division. He was formerly vice president of marketing for Kollsman Instrument Corp.

New Hydro-Aire sales manager

McGuire

Maurice H. McGuire, former eastern division sales manager for Hydro-Aire Div. Crane Co., Burbank, Calif., has been appointed general sales manager. McGuire's present responsibilities include all pneumatic and hydraulic aircraft, missile, cryogenic, electronic, and nuclear sales activities of the company.

Teree joins Weston Hydraulics

B. R. Teree has joined Weston Hydraulics, Ltd. as market development manager. He will be responsible for the market research and development programs of both the aerospace and the new industrial divisions of Weston.

Teree has been associated with the fluid power industry since 1931. His more recent associations include New York Air Brake, Greer Hydraulics, and Republic Manufacturing—in such positions as director of engineering and vice president of engineering and manufacturing.

He has been chairman of the SAE A-6 Aerospace Hydraulic and Pneumatic Systems and Equipment Committee since 1944. Teree is an Associate Fellow, Institute of Aerospace Sciences; Associate Fellow of the Royal Aeronautical Society of England; and member of ASME and SAE.

Teree

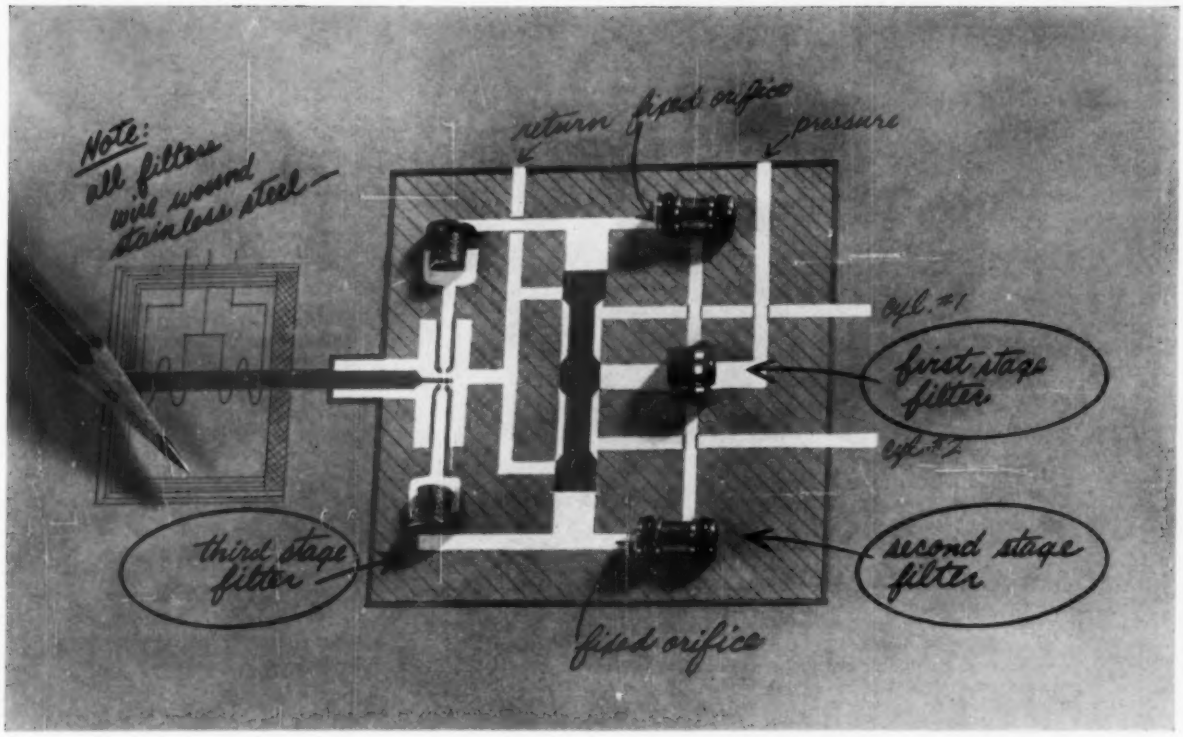
Gross

His faith was in hydraulics

A man who had a dominant role in giving wings to the fluid power industry died Sept. 3. He was Robert E. Gross, chairman of the board of Lockheed Aircraft Corp., a cancer victim at the age of 64. As president of Lockheed during World War II he gave the green light to his engineers for use of hydraulic controls for the aileron system of the famed P-38 fighter. Later, when his engineering designers proposed 100% fluid power control for a commercial transport he again gave the go-ahead. This faith in hydraulics was affirmed when the first Lockheed Constellation flew in 1946.

Vickers opens Dayton office, names manager

The Aero Hydraulics Division of Vickers Inc. Div. Sperry Rand Corp., Detroit has opened a regional sales and service office in Dayton, Ohio. Lawrence C. Immel is the office manager. Prior to joining Vickers, he was manager of the Dayton office of Adel Products Div., General Metals Corp.



THREE STAGE FLUID FILTRATION ADDS EXTRA RELIABILITY TO SERVO VALVE

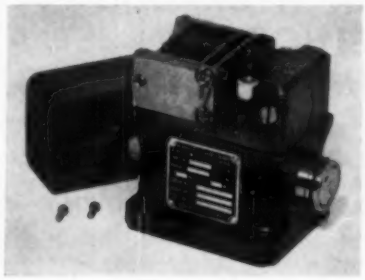
All fluid that passes through the amplifier section of the Hydraulic Research Dry Coil Servo Valve must go through three stages of filtration.

In the first stage the inertia of particles entrained in the flow stream supplements basic filtration. Filter life is enhanced by the washing action of main valve flow on the filter's inner surface.

Second and third filtration stages are strategically located to protect the orifices and nozzles from any possible contamination from within, as well as any that might pass through stage one.

All five filters are wire wound stainless steel. Wire size and winding pitch are accurately controlled for extremely sharp particle size cut-off.

Torque motor is dry coil construction. Coil and magnetic circuitry operate entirely in air media to prevent magnetic particle build-up found in wet coil construction. Stainless steel, unitized power stage provides excellent null stability at varying temperatures.



CHALLENGING ENGINEERING POSITIONS OPEN

HYDRAULIC RESEARCH
and Manufacturing Company

Division of Bell Aerospace Corporation

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MANUAL SHUT OFF

PRIORITY

PRESSURE SWITCH

PRESSURE REDUCER

PRECISION HYDRAULIC VALVES AND COMPONENTS FOR FLIGHT CONTROL SINCE 1943

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Whether you need servo components or a complete packaged system, talk to the Raymond Atchley Division.

Exclusive features, like Atchley's Jet-Pipe servovalve (above), are one good reason. The Jet-Pipe can pass fluids with contaminants as large as 200 microns and still operate perfectly.

Another good reason is Atchley's years of experience and know-how in designing complete servo control systems for the military and industry — from missile control to industrial automation.

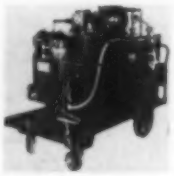
If your concern is a system involving electronic, hydraulic, or pneumatic servo controls, let Atchley wrap it up for you.

Raymond Atchley Division AUTOMATION SYSTEMS
AMERICAN BRAKE SHOE COMPANY 2339 COTNER AVENUE LOS ANGELES 64, CALIF.

NEW HYDRAULIC FLUID MAINTENANCE METHODS ON JET AIRCRAFT REDUCES PUMP LOSS 80%. OTHER COSTS DROP

PLANESIDE RECTIFICATION REDUCES DAMAGE AND GIVES ADDED FLIGHT SAFETY WITH LESS DOWN-TIME.

Write for your copy of the Briggs Data sheet which describes the full-line of planeside filters and dispensers. See how one nationally known airline cut hydraulic maintenance bills; see how it cuts pump replacement costs to the very bone. Full details are yours, they will point out new ways of hydraulic safety and cost control.



Above is a Briggs 50 gallon filter-dispenser in wide use with a new highly efficient fluid. This and other models can be made to fit into any maintenance program demanding the highest degree of safety and efficient cost reductions.
The filters are available in capacities to suit your needs.

Briggs
PIONEERS IN AVIATION OIL FILTRATION

AVIATION HYDRAULIC FLUID FILTERS & DISPENSERS

THE BRIGGS FILTRATION COMPANY
DEPT. NO. 403, RIVER ROAD, WASHINGTON 16, D. C.

Circle 20 on Reader Service Card

AEROSPACE NEWS

from the fluid power field

Ram-air hydraulic turbo powers British missile

Bloodhound is a British ground-to-air weapons system which is a combination of radar, the missile launcher, launch control post, and workshop. While the missile is on the launcher, hydraulic power is provided by an adjacent launcher plant assembly. However, while in flight, hydraulic power is supplied by a ram-air-driven hydraulic turbo pump and accumulators.

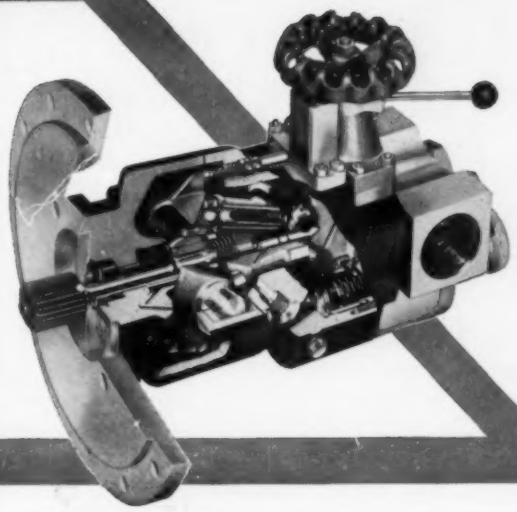
A radar dish in the missile's nose cone collects radar pulses reflected from the target. From these signals, the homing receiver extracts components from the signals which command two double-acting cylinders that move the radar dish to follow the target. These signals also command the wing zero system. The flight control surface on each wing is operated by a double-acting cylinder controlled by the main servovalve.

A hydraulically driven alternator provides electrical power for the Bloodhound while in flight. An accumulator drives the alternator during launching while the pump is coming up to speed.

The Bloodhound, manufactured by Bristol/Ferranti, is loaded onto the launcher while it is horizontal, then the launcher is elevated to firing position by hydraulic power.

NEW HEADQUARTERS BUILDING for General Air Equipment is in Pasadena, Calif. The building contains 2300 sq. ft. of office space and 3000 sq. ft. of shop area. GAE supplies high pressure helium compression systems for the Atlas and Titan missile programs. It is the exclusive distributor in the western United States for Cardair Division of Marmon-Herrington. Also GAE is a dealer for Ingersoll-Rand and Robbins Aviation. ▼▼▼

Nine piston, variable volume, pressure compensated type IA-38-9 pump, designed for use on Ground Support Equipment.



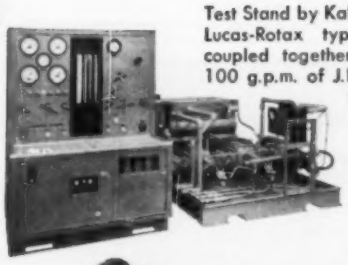
VERSATILITY-PROVEN *lightweight hydraulic* PUMPS AND MOTORS

Well known equipment manufacturers are specifying Lucas-Rotax hydraulic pumps and motors because they offer

- size and weight advantages in the 4 to 104 g.p.m. flow range
- pressures up to 5000 p.s.i.
- low noise level
- other attractive design features

Lucas-Rotax provides full engineering, sales and service throughout North America.

Your hydraulic requirements will be met by contacting Lucas-Rotax Limited, Toronto.



Test Stand by Kahn Company. Three Lucas-Rotax type IP-525 pumps coupled together provide flow of 100 g.p.m. of J.P.4 fuel for testing aircraft equipment.

Marine winches by Timberland-Ellicott are powered by Lucas-Rotax pumps and motors.

Two IA-38 pumps are incorporated in the portable Test Stand by Consolidated Diesel for use in checking out hydraulic system components on fighter aircraft at 5,000 p.s.i.

products of creative engineering by

LUCAS-ROTAX LIMITED

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TRU-SEAL
TEFLON SEAL
PAT. PENDING
Saves hours in piping installations

Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION
7N017 York Rd., Bensenville, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.

1 Thread Tru-Seal on pipe or fitting as far as it will go hand tight. SEAL SIDE

2 Thread pipe or fitting 3 threads into port. Point in desired direction.

3 Tighten Tru-Seal to complete leakproof assembly (only light torque required).

VERSA
EXPLOSION PROOF
Solenoid Valve

■ Now . . . You can get Versa Valves with Explosion Proof Solenoid actuation. This new actuator is available on any series "V" and "T" Valves in sizes from ⅛" NPT to ½" NPT in 2-, 3-, 4- and 5-way types, in side port models or sub-plate models for manifold mounting, and for pressures from partial vacuum to 500 PSIG. ■ These superior valves are completely enclosed units, having no external moving parts and they are virtually trouble free. ■ All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness. ■ For complete information write today for Bulletin #660.

VERSA Valves
VERSA PRODUCTS COMPANY, INC.
150-A COOLIDGE AVE., ENGLEWOOD, NEW JERSEY

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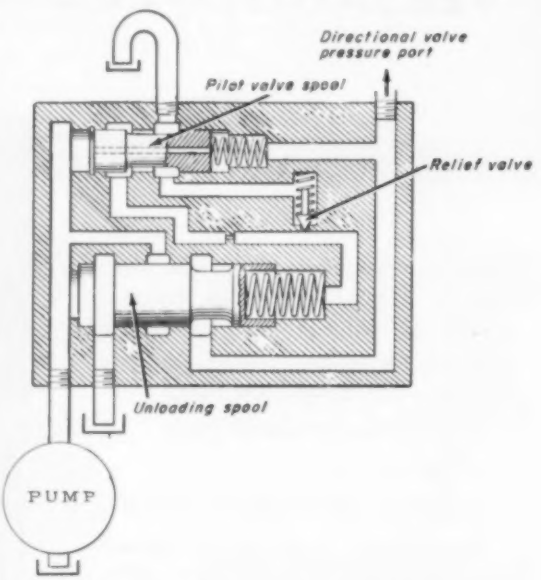
FLUID POWER PATENTS

Unloading Valve

With closed-center, directional control valves, the system pump must operate at relief valve setting when the control valve is in neutral. This operation is inefficient and often produces overheating in a hydraulic system. This patent covers a non-graduated, flow-rate-responsive unloading valve which mounts between the pump and the directional control valve. It unloads the pump when the valve centers.

● **Integral Pilot Controls Main Valve**—The drawing shows the valve in its unloading position. Pump flow enters the valve and is directed to tank through the port at the left of the unloading spool. Pump output holds the unloading spool right against the light spring force as long as the pilot valve spool is shifted right.



When the directional control valve shifts to extend or retract the cylinder, fluid flows out of the chamber at the right of the pilot valve spool. Pressure fluid from the pump shifts the pilot valve spool right. Fluid then flows through the unloading spool. The unloading spool moves left closing the tank port. Pump fluid flows through the recess in the unloading valve spool to the pressure port on the directional control valve.

When the directional control valve centers blocking flow, pressure equalizes on both ends of the pilot valve spool. The spring shifts the pilot spool connecting the unloading valve spool spring chamber to tank. Pump flow opens the unloading valve directing pump output to tank.

U. S. Patent No. 2,977,971 by Charles H. Ruhl, assigned to The New Air Brake Company.

OPENING NEW HORIZONS

. . . in economical power application

98% PLUS OPERATING EFFICIENCY
MORE POWER PER CYLINDER DOLLAR
PROVEN LEAKPROOF OPERATION
GREATEST SELECTION EVER OFFERED
SAFE UNDER SEVERE LOADS
SAFE WITH ALL KNOWN HYDRAULIC FLUIDS
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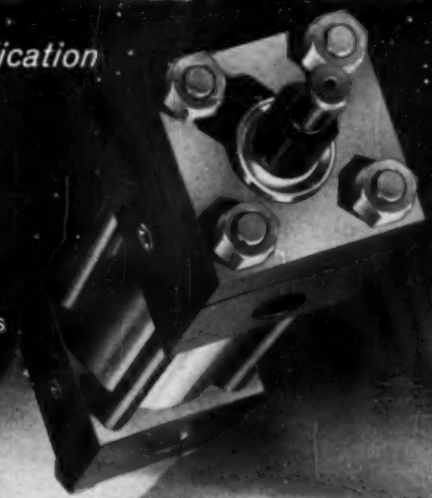
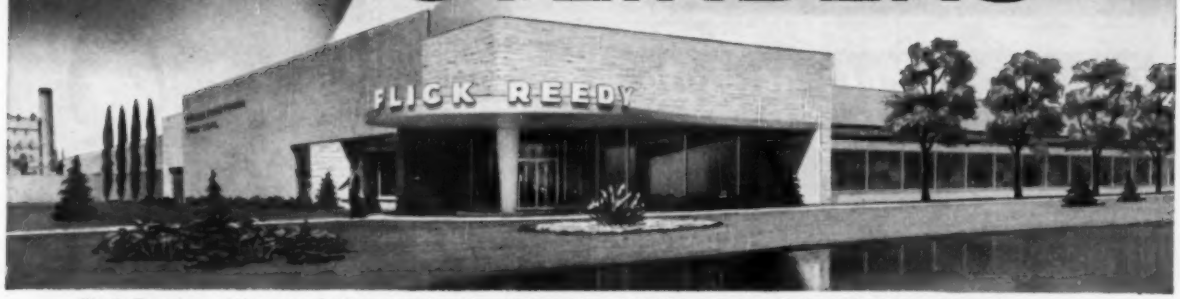
DAMAGE-PROOF PISTON RODS



Miller HYDRAULIC CYLINDERS



Flick-Reedy . . . *Winner of "Plant of the Year" Award and "Silver Anvil" Public Relations Award*

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MORE SAVINGS!

Our ultra-modern, new "Plant of the Year" with its special facilities and operating economies enable us to offer an **extra 10% price savings** on our big "stock" selection of:
Model "H" (Hyd.) Cylinders, 1½" through 8" bores;
Model "J" (Hyd.) Cylinders, 1½" through 14" bores;
Model "A" (Air) Cylinders, 1½" through 14" bores.
Strokes up to 36", cushioned and non-cushioned.

Full Details On Request

Miller Hydraulic Cylinders make impossible applications look easy. With Teflon Seals, Case-Hardened Rods (50-54 Rockwell C), Patented "Shef" Tubing End Seals, and other exclusive *standard* features, these cylinders are practically damage-proof, are ultra-dependable under pressure and temperature extremes, and provide leakproof sealing with ALL hydraulic fluids. Built to *exceed* J. I. C. Specifications, these cylinders are achieving new highs in production and operating economies in thousands of plants. Two great lines: Power-Packed Model H for 3000-5000 psi and Job-Rated Model J for 500-2500 psi. All bores, strokes and mounting styles. Big "Stock" selection for immediate shipment at substantial savings.

Write for literature.

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MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION
7N017 York Road, Bensenville, Illinois
AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
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NEW HEAVY DUTY TYPE KEBBY TANK-TRAPPER

. . . low cost magnetic unit for hydraulic reservoirs

- "DOUBLE MAGNETIZATION"
- CUTS MACHINE DOWN TIME
- REDUCES MAINTENANCE
- MORE DURABLE
- MASSIVE APPEARANCE

Write, wire or phone WO 3-1466 for information and prices.

KEBBY COMPANY
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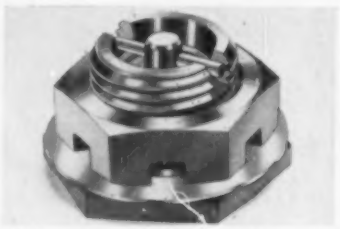
MANUFACTURERS OF MAGNETIC DEVICES

NEW PRODUCTS

Continued from page 54

DRAIN VALVE

Can be mounted flush to any tank exterior surface. Will drain from within .020" of the tank bottom to the absoluate bottom, depending upon the method of mounting. No intermediate drip positions: valve is either intentionally fully open or positively closed. Complete O-ring seal failure is compensated for with a secondary, metal-to-metal seal capable of holding seepage to a few drops an hour under most conditions.



Designation: 5712.—*Bruning Co., Lincoln, Nebr.*

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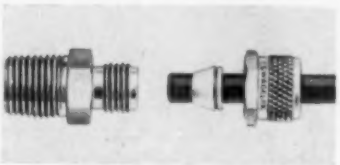
TUBE FITTING

Brass tube fitting body, zytel ferrules, and brass knurled nut provide finger-tight leak-proof assembly with polyethylene tubing for vacuum or pressure applications. Wrench pad on the knurled nut for wrench use. Inserts are not needed.



Stock sizes ¼" and ⅜" O D tubing. —*Crawford Fitting Co., Cleveland, Ohio.*

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HYDRAULIC ROTARY ACTUATOR

Smooth, controlled, cushioned deceleration at the limits of rotation. Special feature guarantees device will not back-off under sustained loads, vibration, or shock. It can be stopped at any angle and will stay put. Field servicing without disturbing the hydraulic lines or using any special tools.

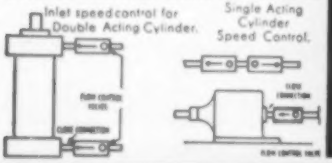
Continued on page 118

Get Easier, More Accurate Cylinder Speed Control with Pneu-Trol® VALVES IN AIR OR HYDRAULIC USE

2,000 (brass or aluminum) and 5,000 (steel) p.s.i.

Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check Valve and Needle Valve incorporate single function features of Flow Control Valve. All valves available in S female pipe sizes — ⅛" to ¾". Valve bodies are made from brass, aluminum, steel or stainless steel. Attractive Prices — Immediate Delivery.

Write for Illustrated Circular and Price List.



AUTOMATION AUTO-PNEUMATICS INC
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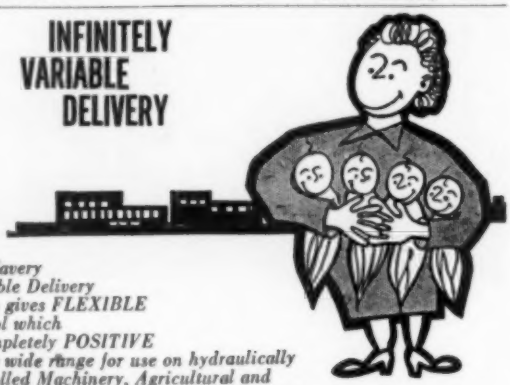
INFINITELY VARIABLE DELIVERY



The Savery Variable Delivery Pump gives FLEXIBLE control which is completely POSITIVE over a wide range for use on hydraulically controlled Machinery, Agricultural and Factory lifting gear, Oil Burner equipment and hydraulics for AUTOMATION

SAVERY PUMPS have a proven record of great reliability in the METERING of chemicals and are used by VIKING ENGINEERING CO., Salford, in their renowned equipment for the production of POLYURETHANE Foams. If you will send full particulars of the properties of any chemicals you wish to pump or meter our Research Department will give you a prompt opinion of the ability of our equipment to handle them.

Tests can be carried out on your own materials and a candid and confidential report given with the minimum delay.

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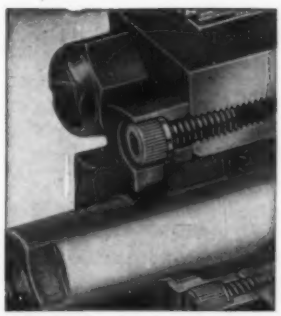
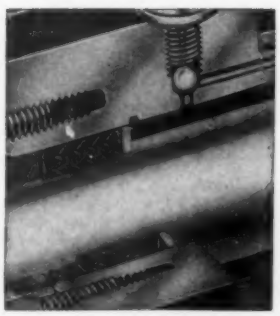
Savery HYDRAULIC PUMPS

Circle **100** on Reader Service Card

Do the cylinders you buy include these quality features?

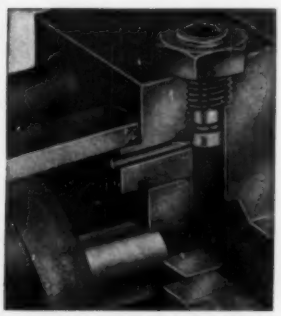


ROD GLAND—Easily removed. No need to loosen tie rods. Cuts maintenance time in half. Phenolic bearing insert will not score rod. Cuts replacement cost to a minimum.

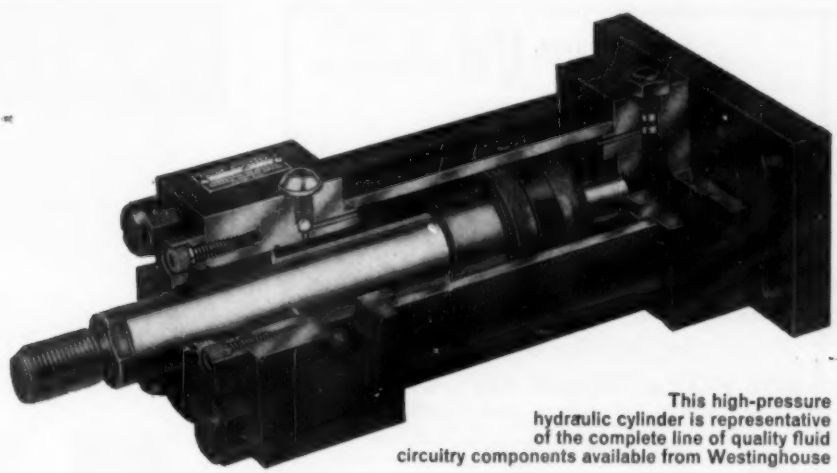


ROD PACKING—Interlocking multiple lip seals require no adjustments; remain flexible under fluid pressure. Wear compensating function eliminates frequent replacement.

PISTON—Phenolic piston will not score tube. Packing cups used for proven long life and seal. Cups are easily replaced. Piston positively locked to rod.



CUSHION—Minimum clearance between piston and Meehanite Bushing combined with micrometer metering give stop cushioning efficiency and a wide adjusting range.



This high-pressure hydraulic cylinder is representative of the complete line of quality fluid circuitry components available from Westinghouse

if not, the chances are, your maintenance costs are higher than necessary. For more information about Quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A3-56.00.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

WESTINGHOUSE AIR BRAKE COMPANY

INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

NEW PRODUCTS

Specifications: Operates on pressures to 5000-psi and requires a very low flow of hydraulic fluid.

Angular rotation to 200 degrees. Torque output ranges from 0 to 500,000 in-lbs. Not significantly affected by temperature variations −65 F to 165 F. O-ring seals used throughout.—*Menasco Mfg. Co., Burbank, California.*

Circle **321** on Reader Service Card

DIVIDER-COMBINER VALVE

Equal division or combination of pump output or return flow is provided by this valve. For use where two hydraulic actuators must work in unison. Gives even operation of two cylinders and proportional piston speeds. Also available factory-calibrated to any unequal combination, such as 40-60%, 45-55%, etc. May be ganged to synchronize multiple elements.

Specifications: One 1" NPTF port and two ¾ NPTF ports. Pressures up to 3000 psi. Weighs 2.4 pounds.

Designation: Model 1467.—*Waterman Hydraulics Corp., Evanston, Illinois.*

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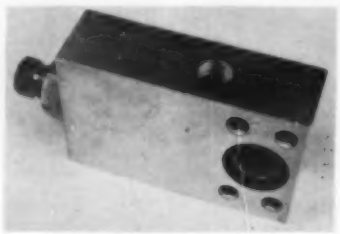
RELIEF VALVE

Direct-operating relief valve, engineered for rapid response, features unusually low differential between



opening and full flow. Pressure control is by simple adjustment of a single set screw with lock nut. Used both as original equipment and service replacement.

Specifications: Designed for mounting on all hydraulic pumps having standard SAE ½" 4-bolt connectors. Capacity to 3000 psi.

Designation: Model 513.—*J. E. Myles, Inc., Detroit.*

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O-SEAL FITTINGS

High pressure piping systems can be installed, modified, relocated or positioned through a full circle arc for handling pressures to 6000 psi using only hand-tight connections with the new O-seal system. Combining O-ring fitted tailpieces with smooth face threaded pieces, tees or elbows and a union nut, leak-proof connections can be made or broken by hand.

Specifications: Standard sizes from ¼" to 2" for 1500 or 6000-psi service as unions or in combination with O-seal globe, check or relief valves.

Designation: CPV O-Seal System. —*Combination Pump Valve Co., Philadelphia.*

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SERIES **UH** —3500 to 6000 psi HYDRAULIC

ULTRA HIGH PRESSURE
Hydraulic Cylinders
FOR EXTRA-TOUGH APPLICATIONS!

- Sheffer-pioneered tapered cushion piston decelerates motion gradually, minimizing "cushion entrance" shock and providing faster operation.
- Square head, compact design, requires less space.
- New tie-rod design for greater shock load capacity.
- Multi-lip rod packing is self-adjusting to wear and removable without disassembly of cylinder.
- Ports—straight thread or flanged, to eliminate leaks.
- Full range of bore sizes, 2" - 12". Seven standard mountings!

Write, NOW, for NEW full-color Bulletin No. 461

Other standard cataloged series cylinders up to 3500 psi in bore sizes 1-⅛" thru 14". Larger bores on application.

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Exclusive Canadian Licensee

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Sold by Leading Distributors Internationally
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PRECISION ENGINEERED

FOR ANY **TIME** **DELAY**

YOU NEED...

FROM 1 SECOND TO 3 HOURS
Write for Bulletin 300 describing 8 different types.

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measurement and control

OF PRESSURE AND DIFFERENTIAL PRESSURE

DELTADYNE® SWITCHES
Pat. No. 2,942,572
Adjustable for signalling pressure and differential pressure from 0.25" wc to 200 psi (or psid) in systems to 5000 psi and −65° to +275°F; leak-proof. Units sound alarm, light bulb, turn motor on or off, operate valves—remotely or in place. **$40 to $75**

DELTADYNE INDICATORS
Adjustable and non-adjustable. Actuation 0.01 to 100 psi (or psid). For same pressure/temperature as switches. Red button pops to give visual indication of overpressure. **$22 to $85**

DELTADYNE GAUGES

For system pressures to 3000 psi; indication from 0 to 60 psi differential; leak-proof—no moving seals; high-visibility scale. **$92**

Extended pressure and temperature ranges available in all instruments.

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NEW ACCURACY!

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- Process industries (chemical, petroleum, fuels)
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Read or control tank levels, and pressure drops across filters, heat exchange orifices for flow metering, gas adsorbers and many other types of equipment. Learn more about the cost and service advantages of these units.

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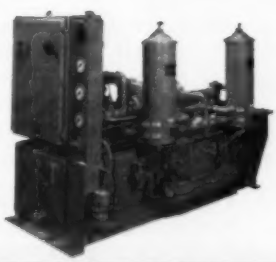
Talk over your special needs with the Cardwell Service Engineer in your area.



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- **No sliding metal-to-metal contact**
- **May be used *With* or *Without* Lubrication**
- **Dead Seal Closing**
- **Full internal porting on all sizes**

Humphrey makes the Simplest Piloted Valve in the World

Inside mechanism of Humphrey "Quick-Dump" Valve

No. 250A ¼" 2-way or 3-way NC piloted Humphrey Valve
List $6.25

No. 125A ⅛" pilot-operated "Quick-Dump"

No. 500A ½" pilot-operated "Quick-Dump"

No. 250-4A ¼" 4-way piloted "Quick-Dump"

This is a full ¾" Humphrey "Quick-Dump" piloted air valve delivering 80.04 cfm at 100 psi.

Humphrey has shrunk the valve size and simplified the inside, thereby improving valve performance, lengthening service life, and making installation easier.

Short stroke (.063") plus fast response and built-in quick exhaust give cycling speeds up to 10 cps. Positive dead-seal closing—may be used for valving vacuum down to 5 microns, with air pilot. (Specify vacuum when ordering.) Complete separation of piloting medium from medium being valved.

No lubrication is required. You save cost of oilers, simplify piping, and get oil-free air. (Over-lubrication does not affect the valve.)

Mail coupon today for literature and prices on the Humphrey "Quick-Dump" line.

HUMPHREY PRODUCTS DIVISION
General Gas Light Company
Box 2008 Kalamazoo, Mich.

HUMPHREY *"Quick-Dump"* VALVES

Mail this Coupon for Literature and Prices on Humphrey Piloted—Manual—Cam-operated—Electric Valves

Humphrey Products Div.
General Gas Light Co.
Box 2008, Kalamazoo, Mich.
Please send literature and prices on "Quick-Dump" Valves. We are particularly interested in _____ *valves.*

Firm Name _____
By _____
Street No. _____
City _____ State _____

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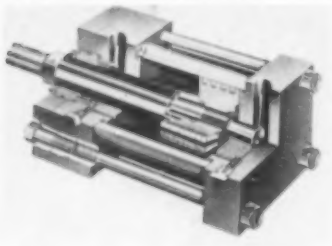
NEW PRODUCTS

INTERCHANGEABLE HYDRAULIC CYLINDER



Hydraulic cylinder is dimensionally interchangeable. Tie rod construction, and removeable with only a wrench. Piston rods are high tensile strength steel, hard chrome-plated. Four different piston packings available. For air and water applications also. Pistons are 1-piece, fine grain alloy cast iron, threaded and pinned to the rod. Cylinder tubes are micro-finished seamless steel sealed with O-rings placed to eliminate extrusion. Tapered cushions eliminate cushion adjusting screws. Catalog available.

Specifications: Meet or exceed JIC standards. 1⅛" through 14" bores, with 18 mountings. For operation to 3500 psi.

Designation: HH series.—*The Sheffer Corporation, Cincinnati.*

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DASHPOTS

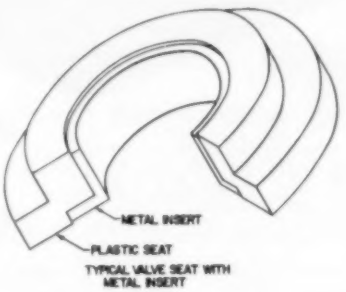
Precision moulded, single or double acting dashpots are designed for a wide range of energy absorption uses and rigidity under high loads. Sixty-six models absorb energy from 1 to 886,000 inch-pounds, from smallest model (1-⅝" long by ½" diameter) to largest model (70" long by 8-½" diameter). Various

end fittings.—*Taylor Devices, Inc., North Tonawanda, New York.*

Circle **326** on Reader Service Card

VALVE SOFT SEAT

Disc-type plastic valve seat with metal insert retains soft-seating advantages such as elimination of galling and scoring; and with-



stands a very high fluid velocity, with the metering characteristics of hard-seating. The bottom of the plastic seat has been counterbored to receive a flanged metal bushing that actually forms the seat orifice. The washer-shaped section of the bushing also prevents seat deformation or deflection due to pressure surges. The upper and lower surfaces of the plastic seat are sealing surfaces.—*Robbins Aviation, Inc., Los Angeles.* ▼▼▼

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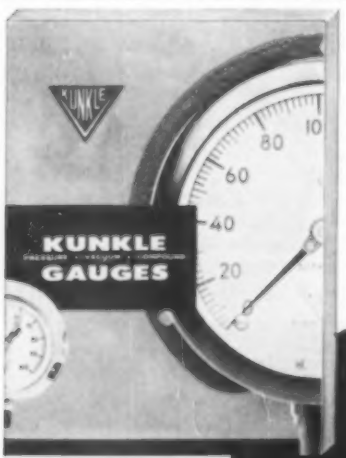

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FOR PROCESS AND POWER INSTRUMENTATION

New COMPREHENSIVE CATALOG AVAILABLE ON REQUEST

Engineering data makes specifying the right gauge quick and easy

COMPLETE LINE

- Ranges from 15 p.s.i., or 30 inches of vacuum, to 20,000 p.s.i. in bronze, stainless steel and other alloys.
- Low pressure and liquid level bellows-actuated gauges.
- Missile and rocket GSE gauges.

KUNKLE VALVE CO., INC. 121 SO. CLINTON ST. FORT WAYNE, INDIANA

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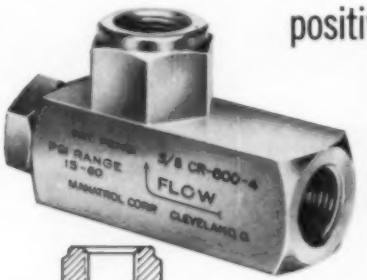
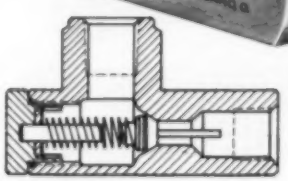


positive-action compact right angle CHECK-RELIEF VALVE



simplifies installation and allows easy access to internal parts without removal from line.

- **internal cracking pressure adjustment is completely tamper-proof.**
- **guided poppet with non-extrudable seal insures quiet, chatter-proof action and a positive shut-off.**
- **excellent re-seating characteristics.**
- **minimum pressure drop prevents loss of fluid power.**

- for use with air, oil, gas, water, other fluids.
- operating pressure up to 5000 psi.
- cracking pressure ranges from 5 to 150 psi.
- standard sizes: ¼, ⅜, ½, ¾, 1, 1¼.

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THE MANATROL Corp.
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COMING IN JANUARY

Hydraulics & Pneumatics

6th Annual DESIGNERS GUIDE ISSUE

Includes:

- 100 pages of detailed specification charts
- Fluid Power Products Review—featuring 275 products introduced in 1961.

Charts will give you material and dimensional specifications, capabilities, operating and constructional features of:

Accumulators	Hydraulic Fluids
Aftercoolers	Oil Coolers
Air Compressors	Packings & Seals
Air Motors	Pressure Gauges
Air-Line Lubricators	Pressure Switches
Boosters	Pumps
Cylinders	Quick-Connect Couplings
Filters	Rotary Actuators
Flexible Shaft Couplings	Rotary Joints
Fluid Motors	Tube Fittings
Hand Pumps	Tubing
Hose, Fittings & Assemblies	Valves

Extra copies will be available at $1.00 each.

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NEW FILTER

with

FILTER CONDITION INDICATOR*

eliminates need for periodic service

A quick glance at the pressure gage on this new hydraulic line filter tells you when its element needs cleaning or replacement . . . warns of impending pressure build-up *before* the built-in by-pass valve can open and allow circulation of unfiltered fluid . . . makes unnecessary the costly and wasteful procedure of inspecting or changing elements at periodic intervals.

It's a big half-gallon filter, with choice of interchangeable monel wire cloth or phenol treated paper elements. Inlet and outlet ports are full 1¼" NPTF. Pressure drop at flow rate of 60 gpm is only 5 psi when using the 200-square-inch, 100-mesh, wire cloth element.

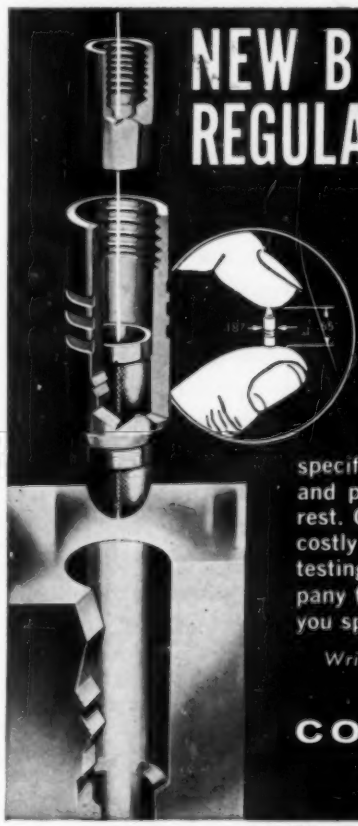
Filter may be installed in either the suction line (between tank and pump) or the return line (between control valve and tank), and the element is easily accessible.

***Amazing fact:** The price of this new filter is only* **$23.50** *complete (slightly higher with wire cloth elements).*

GRESEN
MANUFACTURING CO.
405-35th AVENUE N.E., MINNEAPOLIS 18, MINN.

GRESEN HYDRAULICS

NEW BETTER WAY TO REGULATE FLUID FLOW



LEE JET

Simplest, most accurate, most economical jets ever developed! Insert LEE JETS into reamed holes and lock and seal them by pressing pin into the jet. You specify either the hole size or the flow and pressure drop. LEE JETS do the rest. Quick, easy installation eliminates costly assemblies, seals, threads, flow testing and filter design. The Lee Company flow tests the jets to any tolerance you specify.

Write for full details

LEE COMPANY
WESTBROOK
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NEW LITERATURE

Continued from page 63

BALL VALVES

Oil, chemical, water, steam and gas-handling, top-entry ball valves are made from stainless steel and cadmium-plated carbon steel bar stock. Exploded view, photos, charts, drawings.—*Strong Co., Conneaut, Ohio.*

Circle **416** on Reader Service Card

VALVES & CYLINDERS

Air valves (size ¼" to 1", pressures to 150-psi) and hydraulic valves (size ¼" to 2", pressures to 3000 psi) are discussed; complete line of operators is shown. Hydraulic cylinders (size 1½" to 10", pressures to 3000 psi) and air cylinders (size 1½" to 12", pressures to 150 psi) are described. Specifications to JIC requirements. Line drawings and photographs of keeper ring and tie rod designed cylinders. Over 900 models. Power units with capacities to 40 gpm included. Distributor list.—*Rivett Lathe & Grinder, Inc., Boston.*

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DEPENDABILITY

THESE HANDS SHAPE the quality of hydraulic cylinders at CROSS Manufacturing Company. These hands sense the mettle of materials — deliver uncompromising machine artistry that promises dependability. These hands dare to test their skill with rigid, station-by-station inspection to assure conformity to the highest standards. For a hydraulic cylinder built to withstand severe pressures, corrosive atmospheres and violent stresses— look to CROSS — a complete line of reliable hydraulic cylinders for all industrial applications.

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CROSS Engineers Available to You for Free Consultation!
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3000-PSI CONTROL VALVES

Complete line of 2-, 3-, and 4-way valves in eight sizes from ⅜" to 3" are explained with tables, flow diagrams, & charts. Available with hand lever-, clevis-, roller-, and hydraulically-operated operators. Solenoid pilot operators with built in checks and adjustable outflow chokes can be mounted on all valves. Bulletins 80200-A, 80300-A.—*The Oilgear Co., Milwaukee.*

Circle **418** on Reader Service Card

UNIONS, PLUGS, FITTINGS

Folder has photos of 78 tube fittings with catalog numbers and descriptions. Available in aluminum, steel, stainless steel and brass.—*Linair Engineering, Inc., Inglewood, California.*

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LOW PRESSURE VALVES

Bronze valves, angle, gate, globe, and check, ⅛" to 6", manual control. Handles and swivel cocks are shown. Cross reference compares line with ten competitors. Weight table gives estimates to tenths of a pound for all 14 valve sizes. Solenoid valves with coils for all standard voltages ac or dc. Models from ⅛" to 1". Pressure differential controls designed to maintain a constant difference between two pressures are suitable for operating pressures from 20 to 1800 pounds. Bulletin 800-A.—*Detroit Controls, Div. American-Standard, Detroit.*

Circle **420** on Reader Service Card

AIR CYLINDERS

Squair-Head line specifications completely covered in 48-page engineering data book. 28 pages of dimensional charts, selection guide, and force charts, including accessories and maintenance information. Bore sizes 1½" to 14". Brief ordering info. Area computation tables. Bulletin SQ-61.—*The Tomkins-Johnson Co., Jackson, Mich.*

Circle **421** on Reader Service Card

SMALL CYLINDERS

Cylinders for air service to 500 psi and hydraulic service to 1000-psi are covered. Bore sizes ¾", 1", 1½". Features include large ports for fast actuation, Quad-ring rod seal for improved wear resistance,

solid brass ends with hex or flats for mounting ease, ¼" wall safety factor. Parts list contains material specifications. Mountings diagrammed. Ordering info. Series A, Catalog 101.—*Catching Engineering Co., Brookfield, Illinois.*

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COOLERS & CONDENSERS

Horizontal core, air-cooled heat exchangers for air, water, gases. Catalog 561 covers structural features of cooling sections and cores, has application illustrations, dimensioned drawings, specifications, lists of accessories, and unit nozzle selection charts. Diagrams show cooling methods.—*Young Radiator Co., Racine.*

Circle **423** on Reader Service Card

ELBOWS & RETURNS

Data sheet TF-511 covers short radius, extra-strong 90-deg elbows and 180-deg returns. 1½"-8" nominal pipe sizes. Charts show dimensions. Wall thicknesses follow ASA B36.10 for double extra-strong wall pipe. Dimensional tolerances follow ASA B16.9—*Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.* ▼▼▼

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New MBC *twinlife* **SUMP STRAINERS**

save time, money and space

TWO ELEMENTS INSTEAD OF ONE

- Two to three times the filter area for twice the filter life—even more
- Less downtime for cleaning
- Lower unit area cost
- 5 GPM to 50 GPM capacities
- 140 micron particle retention (10 to 238 micron on order)
- Monel element (standard)
- Mag field and/or guard optional

Precision weavers for over 100 years. Millions of Michigan strainers in use.

MBC **MICHIGAN WIRE CLOTH COMPANY**

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OIL LEVEL GAUGES

- FLUSH-MOUNTING
- DIRECT READING
- HEAVY PATTERN
- EASILY INSTALLED

TYPE 550 AVAILABLE IN 4 STANDARD PRODUCTION SIZES WITH 4", 6", 8" AND 12" LONG SIGHT OPENINGS.

DESIGNED FOR USE ON HYDRAULIC AND LUBRICATING OIL RESERVOIRS AND OTHER LIQUID LEVEL APPLICATIONS.

MODELS AVAILABLE FOR:

- MINERAL OILS
- GLYCOL-WATER SOLUTIONS
- WATER-OIL EMULSIONS
- PHOSPHATE ESTERS
- LOW PRESSURE SERVICE

FOR COMPLETE INFORMATION WRITE

FEDERAL BRASS MFG. COMPANY

ELMIRA 2, N.Y.

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The speed control for air and oil—$3.45 (⅛"-¼")

Ross "CUB"

Now a speed control valve that regulates your cylinder movement with precision and sureness, but which lists at 3.45 each. And despite its lower costs, "CUB" features the same high quality of design and workmanship you've come to expect from Ross. "CUB'S" design stresses trouble-free operation and easy maintenance. CUB is small, aluminum, lightweight and suitable for liquid service. If you use speed controls, by all means call your Ross representative or write us.

Ross OPERATING VALVE CO.

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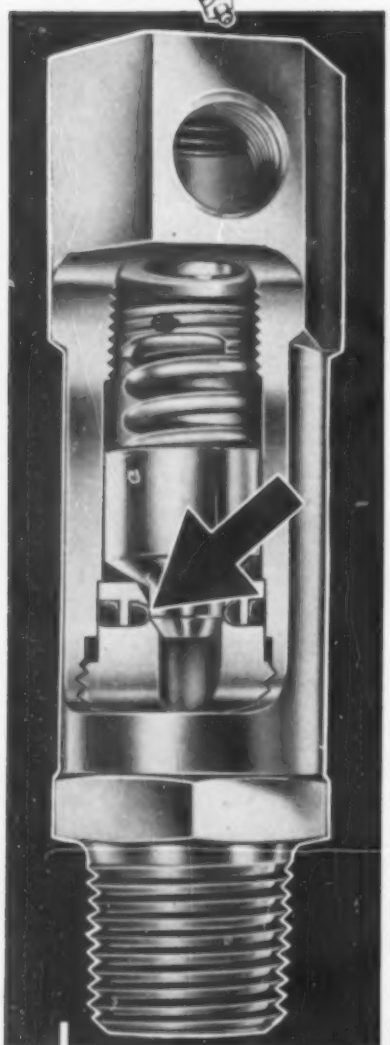
RELIEF

NOW! The exclusive patented Kep-O-Seal flexible seat is available in this practical, economical relief valve. The efficient combination of metal-to-metal and resilient seal seating provides superior performance with simple design. KEP-O-SEAL Relief Valves have tamper proof internal adjustment with Nylok® inserts to assure positive setting. High in quality, low in cost and remarkably quiet, the KEP-O-SEAL Relief Valve is a proud addition to the growing line of Kepner "Cost-Engineered" Products. Write for data sheet.

Kep-O-seal®



KEPNER PRODUCTS COMPANY
7321 West 59th Street
Summit Illinois

Circle 68 on Reader Service Card

POST SCRIPTS OF INDUSTRY

News about people, manufacturers and sales organizations

Watts appoints Colter

Watts Regulator Co., Lawrence, Mass. has named John S. Colter as manager of the Industrial Div. Colter will handle sales and merchandising of Watts' pneumatic specialties and industrial products. He was sales engineer for the Foxboro Co., Foxboro, Mass. before joining Watts.

Colter

Gates

Gates heads firm

The Board of Directors of Gates Rubber Co., Denver, chose Charles C. Gates to succeed his late father as president. He worked in the engineering department until 1949 when he was named a vice president. He became executive vice president in 1958.

Hydreco promotes two

Hydreco Division, New York Air Brake Co., Kalamazoo, Michigan announced two promotions: Richard R. Mease is the new manager of OEM sales; Charles B. Blackburn replaces Mease as manager of parts and services. Mease has been associated with Hydreco since 1955 in various sales, engineering, and production capacities. Blackburn has been Hydreco's sales representative in the Eastern territory since joining the company in 1958.

Mease

Blackburn

Bendix Filter names sales engineer

Joseph A. Levito has been appointed sales engineer in the mid-atlantic states region for Bendix Filter Div. of The Bendix Corp., Madison Heights, Michigan. Headquarters will be Philadelphia. Levito will handle the complete Bendix line of air, hydraulic, and fuel filters, and provide application engineering assistance to aircraft, missile, and industrial filter users.

Westinghouse Air Brake names marketing director

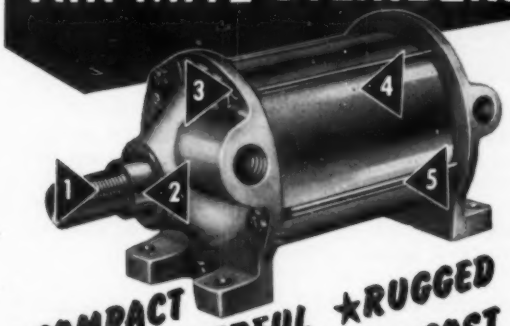
P. E. Dutcher has been appointed director of marketing of the Industrial Products Div., Westinghouse Air Brake Co., Wilmerding, Pa. Dutcher came to Westinghouse from Barrington & Co., New York, a consulting firm. Prior to that association he served with a number of companies in sales management and engineering management positions.

Hanna Engineering head dies

Arthur F. Jensen, former president and board chairman of Hanna Engineering Works, died October 18th. He was a founder and director of the National Fluid Power Association and member of several fraternal organizations. Jensen served as adviser to Hanna for the last two years.

Circle **4** on Reader Service Card

AIR-MITE AIR CYLINDERS



★COMPACT ★POWERFUL ★RUGGED ★LOW COST

AIR-MITE Cylinders—made in Single or Double Acting Series, in 4 mounting types, are high quality cylinders at a low price. Simple, rugged design and compact construction give them long life, permit easy mounting on jigs, fixtures, tools, or machines. Used wherever power holding, pushing, pulling, or lifting is required, AIR-MITE Cylinders will meet your most exacting requirements of dependability and long life. Write for complete catalog and prices.

QUALITY FEATURES:

1. Ground and polished steel ram
2. Bronze oilless ram bushing
3. High strength aluminum alloy cylinder heads
4. Brass, true-bore cylinders
5. Five steel tie rods

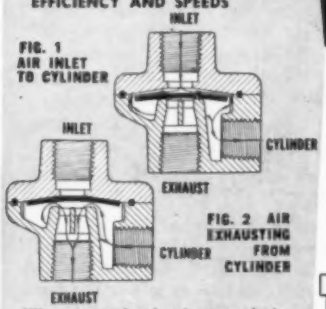
92

AIR-MITE DEVICES, INC.
4401 W. Kinzie St., Chicago 24, Ill.

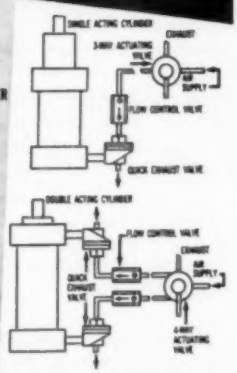
NEW! Pneu-trol® QUICK EXHAUST VALVE

Fast air dumping AT THE CYLINDER permits use of smaller valves and piping . . . INCREASES EFFICIENCY AND SPEEDS

Operating Pressures:
1 to 125 PSI
For 3/8" and 1/4" pipe sizes



When control valve is opened air pressure seals exhaust port and diaphragm is deflected permitting air to pass thru the cylinder port (Fig. 1). When inlet pressure is relieved (by actuating valve in control circuit) the buildup of cylinder return pressure closes inlet port (Fig. 2) snapping the diaphragm off the exhaust port allowing instantaneous evacuation of exhaust air. *Write for complete details, specifications and prices.*



TYPICAL APPLICATIONS of Quick Exhaust Valves in Single and Double Acting Cylinders. Because exhaust air is dumped at cylinder, smaller diameter piping and smaller selector valves can be used

AUTOMATION AUTO-PONENTS INC
AUTO-PONENTS INC.
2919 Grant St. • Bellwood, Illinois

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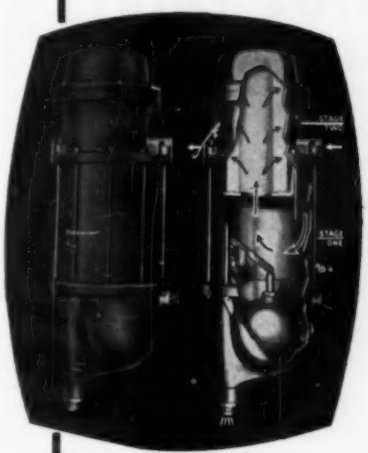
Get clean, dry oil-free compressed air!

Use this dependable

WILKERSON

heavy-duty, float-draining

FILTER



Your paint sprayers, air cleaners, agitating devices, instruments and air tools are not delivering full profit potential if contaminants destroy efficiency and long life.

The Wilkerson ARID-AIR Filter

- ★ Individual moisture-separating and filtering chambers provide 2-stage action which extends the life of the low-cost cartridge 4 times.
- ★ *Automatically* discharges up to 500 gallons of moisture per hour.
- ★ Removes particles as small as 3 microns in size.
- ★ Available from ½" to 2" P. T. up to 425 CFM with only 1.10 to 3.50 pressure drop. Maximum pressure 250 PSI.

WRITE TODAY

for complete ARID-AIR information contained in circular 1027 and name of your nearest Wilkerson distributor.

WILKERSON CORPORATION

Dedicated to keeping the NEW in pNEUmatics

1643 West Mansfield, Englewood, Colorado

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INCANDESCENT TYPE
Takes 6, 14, or 28 volt midget flange base incandescent lamps. Only 1 11/16" long, including terminals. Many transparent or translucent lenses available.

NEON TYPE—Built-in Resistor
Hetherington L15,000 Series, to MS25257. Has internal resistor, measures only 1 3/4" long including terminals. Uses MS25252-NE2D neon lamps on 115 volts.

MIL-L-6723 (ASG)

INDICATOR LIGHTS

These miniature two-terminal indicator lights provide the extra measure of reliability required for critical military and commercial aviation and marine needs. Long plastic lenses fitted with threaded nickel plated brass bushings pipe light evenly throughout lens surfaces . . . remove easily for lamp replacement. Large, silver center contacts are internally spring-loaded for vibration resistance. Anodized aluminum cases have positive-locking panel indexing tabs.

For full details, write for Bulletin L-5a.

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Circle **27** on Reader Service Card

POST SCRIPTS OF INDUSTRY

PARKER-HANNIFIN CORP. . . . John W. Tuohy was appointed sales engineer for industrial pneumatic and hydraulic products, working with the Chicago staff.

FLICK-REEDY CORP. . . . Richard A. Bardos has been appointed field engineer for the Michigan territory.

HYDRAULICS, INC. . . . Eugene H. Libby has been appointed sales manager. He was formerly in sales at Couse & Bolten for 12 years.

PARKER SEAL CO. . . . Two appointed representatives: Alfred Finch in the Washington and Oregon areas, and Pierce R. Tower in certain areas of southern California.

GREER HYDRAULICS INC. . . . Leonard Seeman has been appointed general manager, eastern div., with headquarters in Westbury, N. Y.

KEMCO HYDRAULICS INC. . . . J. L. King has been appointed general sales manager. He will range between the sales headquarters in San Francisco and the general offices in Willits, Calif.

FLUID CONTROLS, INC. . . . E. E. Barone has been named senior methods engineer.

DIXON CORP. . . . New 25,000 square foot plant in Monroe, North Carolina houses production equipment and warehouse space for Rulon and Teflon products.

HUMMEL TECHNICAL PRODUCTS INC. . . . A new branch office: 10 DeHart St., Morristown, N. J. Facility includes sales offices, testing, repair, and component stock.

New distributors

Kaufman Glass Co., Wilmington, Del., has been named an authorized distributor for the Packing Div., Raybestos-Manhattan Inc., Passaic, N. J. for Delaware, Salem and Cumberland Cys. in New Jersey, and Delaware Cy. in Pennsylvania. *Gerard Packing & Belting Co.*, New York, N. Y., has been appointed an authorized distributor for the New York area.

Young Radiator Co., Racine, Wis., has announced the appointment of sales representatives in northeastern Ohio: *Allied Equipment Co.*, of Cleveland and Cuyahoga Falls, Ohio.

MacMillan Hydraulic Engineering Corp., Skokie, Ill., has been appointed by Fluid Power Div., Hale Fire Pump Co., Conshohocken, Pa., as a distributor for hydraulic accumulators. Territory is northern Illinois, northwestern Indiana, and southern Wisconsin.

Parker Fittings & Hose Div. of Parker-Hannifin Corp., Cleveland, announced the following appointments of stocking distributors of its industrial tube fittings and related tube-working tools: *Moody-Price Inc.*, Baton

Rouge, La. and *Meier Bearing Alloys Inc.*, Chicago. Meier will also stock Parker industrial hose and reusable hose fittings. *D & O Engineering Co., Inc.*, Wichita, Kansas has been franchised as a stocking distributor for Parker industrial tube and hose fittings. A distributorship for Crown filters, regulators, and lubricators, products of the Hannifin Division in Des Plaines, Ill., has been granted to *Simco Supply Co., Inc.*, Atlanta.

Hoffman Valves Inc., of Dayton, Ohio, has announced the appointment of *F. W. Hughes and Hughes Industrial Products*, Buffalo, N. Y. as distributor for their line of poppet and spool type valves. The new distributor will cover 8 counties in northwestern New York State and 3 adjacent counties in northern Pennsylvania.

Air-Draulics Co., Phoenix, Ariz., has been appointed hydraulic sales representative for Arizona by Racine Hydraulics & Machinery Inc. *Raymond J. Mannelle*, Pittsburgh manufacturer's representative, has been retained by Racine as district agent for their Construction Products line in Ohio, Pa., W. Va., Del., N. J., Md., and N. Y. C.

Maledco Engineering Co., Glendale, California has been appointed to represent the following companies: Microporous Filters, Anaheim, Calif., Conair, Inc., Glendale, C.V.C. Control Valves, Los Angeles, and Gelman Instrument Co., Chelsea, Michigan. Maledco specializes in airborne and ground support components for the aerospace industry.

Nichols Equipment, Inc., St. Louis is exclusive representative in eastern Missouri, southern Illinois and Arkansas for Master Pneumatic, Inc., Detroit, manufacturer of filters, lubricators, and other compressed air system accessories.

Hofmann Engineering Company, Lyons, Illinois recently appointed *Engineering Sales Co.*, Wellesley Hills, Mass. as distributor for the New England area. Engineering Sales will handle Hofmann's quick-disconnect couplings and vinyl hose.

Baker Engineering Corp., Wichita has been named to stock and distriute ball valves for the Jamesbury Corporation in the Wichita area. Baker also will stock and distribute hydraulic valve actuators, cylinders, and hydraulic power units for Oil-Dyne, Inc., of Chicago in the western half of Missouri, Kansas, and Oklahoma.

J. C. Sprague Co., Detroit has been appointed to represent Waterman Hydraulics Corp., Evanston, Illinois in southeastern Michigan. Sprague will distribute the Waterman line of flow regulators, solenoid valves, and other hydraulic valves.

Fluid Power Ltd., Division of Viceroy Engineering, Toronto, Canada has been licensed by Pokorny Pow-R-Trol Products, Inc., Cleveland to market and service Pow-R-Trol hydraulic checking units, cylinders, valves and other hydraulic equipment in Canada.

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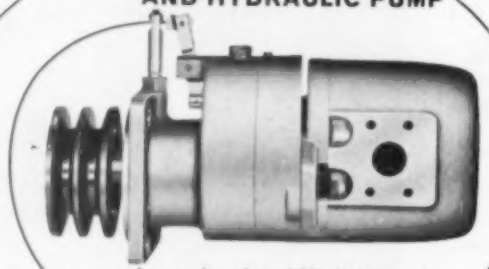

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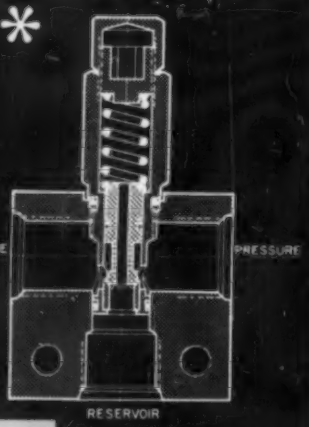

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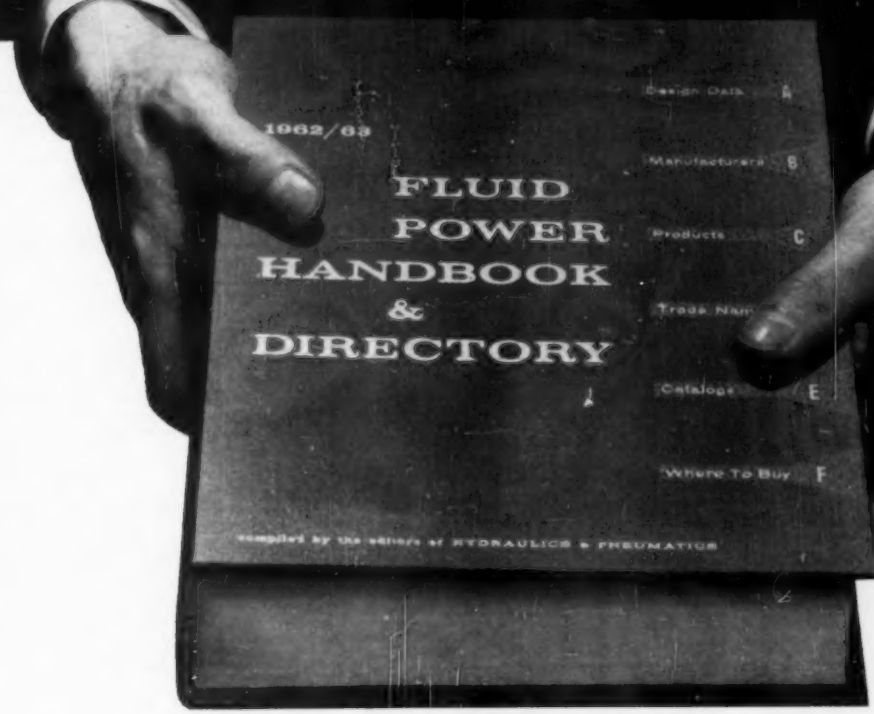

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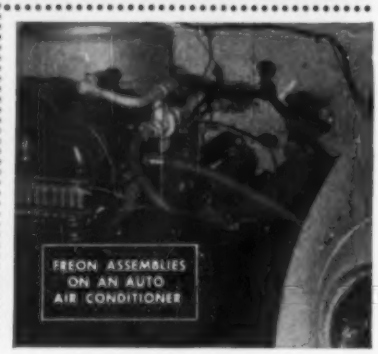

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NAME TITLE

COMPANY

ADDRESS KIND OF BUSINESS (or product manufactured)

CITY ZONE STATE

ADVERTISERS

1	16	31	46	61	76	91	106	121	136	151	166	181	196	211
2	17	32	47	62	77	92	107	122	137	152	167	182	197	212
3	18	33	48	63	78	93	108	123	138	153	168	183	198	213
4	19	34	49	64	79	94	109	124	139	154	169	184	199	214
5	20	35	50	65	80	95	110	125	140	155	170	185	200	215
6	21	36	51	66	81	96	111	126	141	156	171	186	201	216
7	22	37	52	67	82	97	112	127	142	157	172	187	202	217
8	23	38	53	68	83	98	113	128	143	158	173	188	203	218
9	24	39	54	69	84	99	114	129	144	159	174	189	204	219
10	25	40	55	70	85	100	115	130	145	160	175	190	205	220
11	26	41	56	71	86	101	116	131	146	161	176	191	206	221
12	27	42	57	72	87	102	117	132	147	162	177	192	207	222
13	28	43	58	73	88	103	118	133	148	163	178	193	208	223
14	29	44	59	74	89	104	119	134	149	164	179	194	209	224
15	30	45	60	75	90	105	120	135	150	165	180	195	210	225

NEW PRODUCTS

300	315	330
301	316	331
302	317	332
303	318	333
304	319	334
305	320	335
306	321	336
307	322	337
308	323	338
309	324	339
310	325	340
311	326	341
312	327	342
313	328	343
314	329	344

NEW LITERATURE

400	415	430
401	416	431
402	417	432
403	418	433
404	419	434
405	420	435
406	421	436
407	422	437
408	423	438
409	424	439
410	425	440
411	426	441
412	427	442
413	428	443
414	429	444

AEROSPACE DATA

500	515	530
501	516	531
502	517	532
503	518	533
504	519	534
505	520	535
506	521	536
507	522	537
508	523	538
509	524	539
510	525	540
511	526	541
512	527	542
513	528	543
514	529	544

Card Invalid Without Company Name

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9	24	39	54	69	84	99	114	129	144	159	174	189	204	219
10	25	40	55	70	85	100	115	130	145	160	175	190	205	220
11	26	41	56	71	86	101	116	131	146	161	176	191	206	221
12	27	42	57	72	87	102	117	132	147	162	177	192	207	222
13	28	43	58	73	88	103	118	133	148	163	178	193	208	223
14	29	44	59	74	89	104	119	134	149	164	179	194	209	224
15	30	45	60	75	90	105	120	135	150	165	180	195	210	225

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412	427	442
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502	517	532
503	518	533
504	519	534
505	520	535
506	521	536
507	522	537
508	523	538
509	524	539
510	525	540
511	526	541
512	527	542
513	528	543
514	529	544

H&P IS NOW ADDRESSED LIKE THIS:

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MAJOR PRODUCTS MANUFACTURED OR TYPE OF BUSINESS AT THIS ADDRESS

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SIGNATURE

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ASCO now brings you a family of solenoid valves, specially designed for missile applications with tough environmental or operational requirements. Two, three and four way valves are available with standard, explosion-proof or watertight solenoids; sizes range from ⅜" through 2½". Fluids handled include air, liquid oxygen, helium and nitrogen (liquid and gaseous). Valves can be supplied with continuous duty coil windings for 24 volts D-C, and for any other commercial voltages required. All types are packless (hermetically sealed), providing tight shut-off, with no external leakage to atmosphere.

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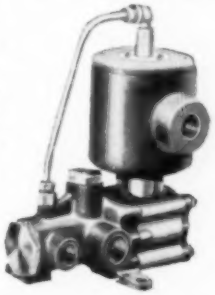

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ASCO Valves

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